

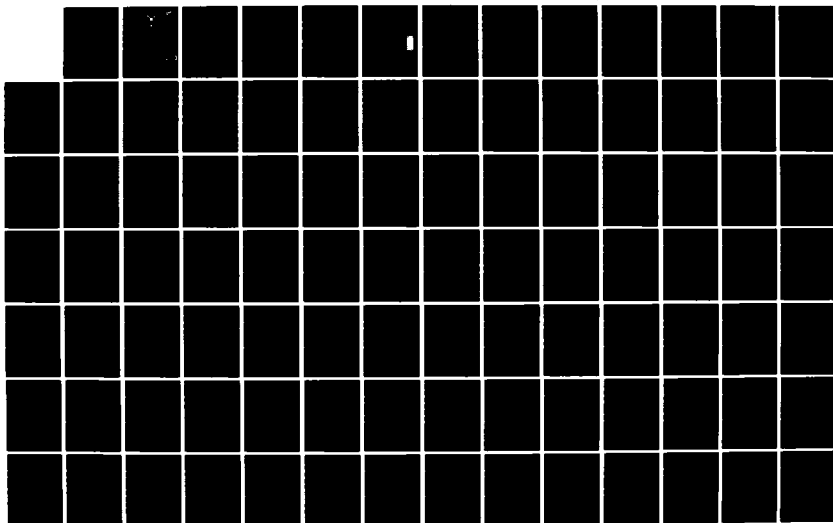
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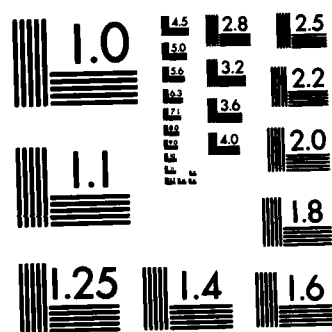
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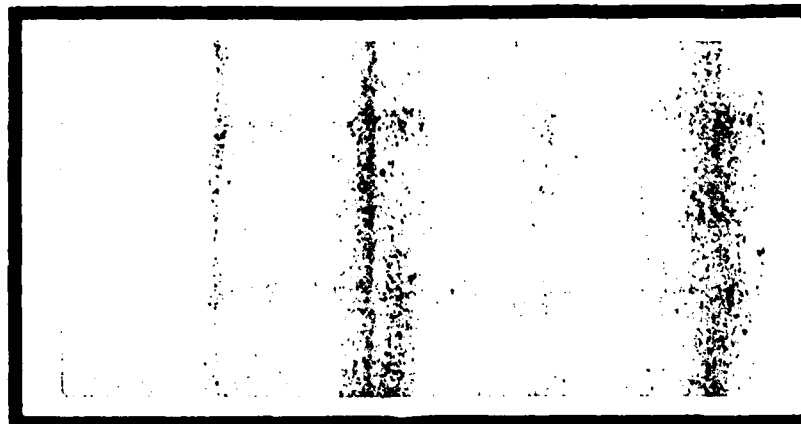




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A COMPUTER SIMULATION OF THE
STRUCTURE OF THE ROYAL AUSTRALIAN
AIR FORCE OFFICER CORPS:
THE ROS MODEL

Christopher L. Mills
Wing Commander, RAAF

LSSR 15-82

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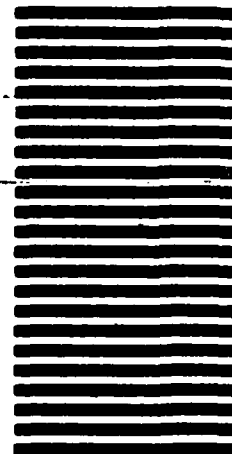
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The purpose of the Royal Australian Air Force (RAAF) Officer Structure (ROS) model is to assist the RAAF Personnel Division to complete its planning and control functions with regard to the Officer Corps. An entity-oriented computer simulation model, isomorphic to the practices and procedures of the RAAF Personnel Division, is used to assist managers to obtain the maximum benefit from the officer manpower resource. The model is goal-seeking in that it seeks to satisfy demands for officer manpower within resource constraints. The processes of manpower demand, resource allocation, loss of officers from the Service, promotion, recruitment and recruitment limits are modeled. Each officer in the Service is modeled, and officers represented in the model are subject to deterministic and stochastic processes as in the "real world." The model progresses in one-year steps, taking data from several source files, plus inputs from the operator who communicates interactively with the model. Extensive output is available to enable managers and analysts to determine significant aspects of the consequent Officer Corps structure.

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A COMPUTER SIMULATION OF THE STRUCTURE OF THE
ROYAL AUSTRALIAN AIR FORCE OFFICER CORPS:
THE ROS MODEL

A Thesis

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Systems Management

By

Christopher L. Mills, BSC
Wing Commander, RAAF

September 1982

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This thesis, written by

Wing Commander Christopher L. Mills

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A handwritten signature in cursive script, reading "John R. Robinson". The signature is written in dark ink and is positioned above a horizontal line.

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Chapter 1

BACKGROUND

Introduction

This study develops an isomorphic simulation model of the Royal Australian Air Force (RAAF) Officer Corps. The primary purpose of the model is to assist manpower forecasting for a period up to ten years from the base year. The Director of Personnel Officers-Air Force, and the Director of Resources Monitoring and Planning-Air Force are co-sponsors for this study.

The required effectiveness of a nation's Armed Services can be determined from the strategic and tactical threats that face the nation. Whether the nation can create a force of the desired effectiveness depends in part on the efficiency of the force, which in turn depends on the quality of both long and short term decisions made by members of the force itself. The quality of these decisions depends to a great degree on the quality of the personnel of the Armed Services.

Creating a Service containing high quality personnel is a demanding task. One approach to the problem is to consider manpower as a resource, and to manage that resource in the way other resources are managed; i.e., use

scientifically proven techniques to maximize the effectiveness and minimize the cost of the personnel of the Service.

Manpower Resource Management Factors

Cost. The most "visible" reason for manpower resource management is the high cost of Service personnel. In most Armed Services, manpower salaries consume about 20 percent of the budget. For example, in the USAF the FY80 Military Personnel Budget was \$M8,416 out of a budget of \$M39,928 (i.e., 21 percent), and in FY81 was \$M8,701 of a budget of \$M45,732 (i.e., 19 percent) (Air Force Report FY/1981, Table 1:29). Even these high figures probably underestimate the total cost of military personnel; much Service activity is devoted to recruiting, training, supervising, housing, and otherwise caring for Service members. The percentage of the available effort devoted to these activities can be directly affected by Personnel Policies. Consequently, given a target degree of Service effectiveness, the cost of achieving the target is very sensitive to the quality of the manpower resource management. Alternatively, given a fixed defense budget, the funds available for weapons acquisition will be affected by funds spent on personnel; again, efficient management of the manpower resource can directly affect force effectiveness.

Lead Time. Little lateral recruiting is possible in the Armed Services. (Lateral recruiting means obtaining

personnel for all levels of the organization who are already trained; e.g., appointing a civilian (say) at Wing Commander/Lieutenant Colonel level on the basis of relevant nonservice experience.) Consequently, building a force of the desired structure is a long term task as filling the Service with skilled personnel can only be achieved by recruiting at a junior level, then providing the necessary skills through a long period of work experience and training. The lead time to develop, say, a senior acquisition manager or a squadron commander may be as much as twenty years. If strategic changes require a change in structure of the Armed Services, such changes may be difficult to achieve because the inertia inherent in the manpower structure can prevent the Armed Services reacting flexibly to changes in the threat. The adaptability of the Armed Services can be greatly enhanced by manpower resource management methods that use scientific forecasting techniques and "feed-forward" control systems to achieve Service goals.

Problem Complexity. Solving problems arising in manpower resource management can be particularly difficult because of their complex, multidimensional nature. An "influence" diagram has been included to show some of the interacting elements. Figure 1.1 shows elements that are central to the problem. Note the large number of

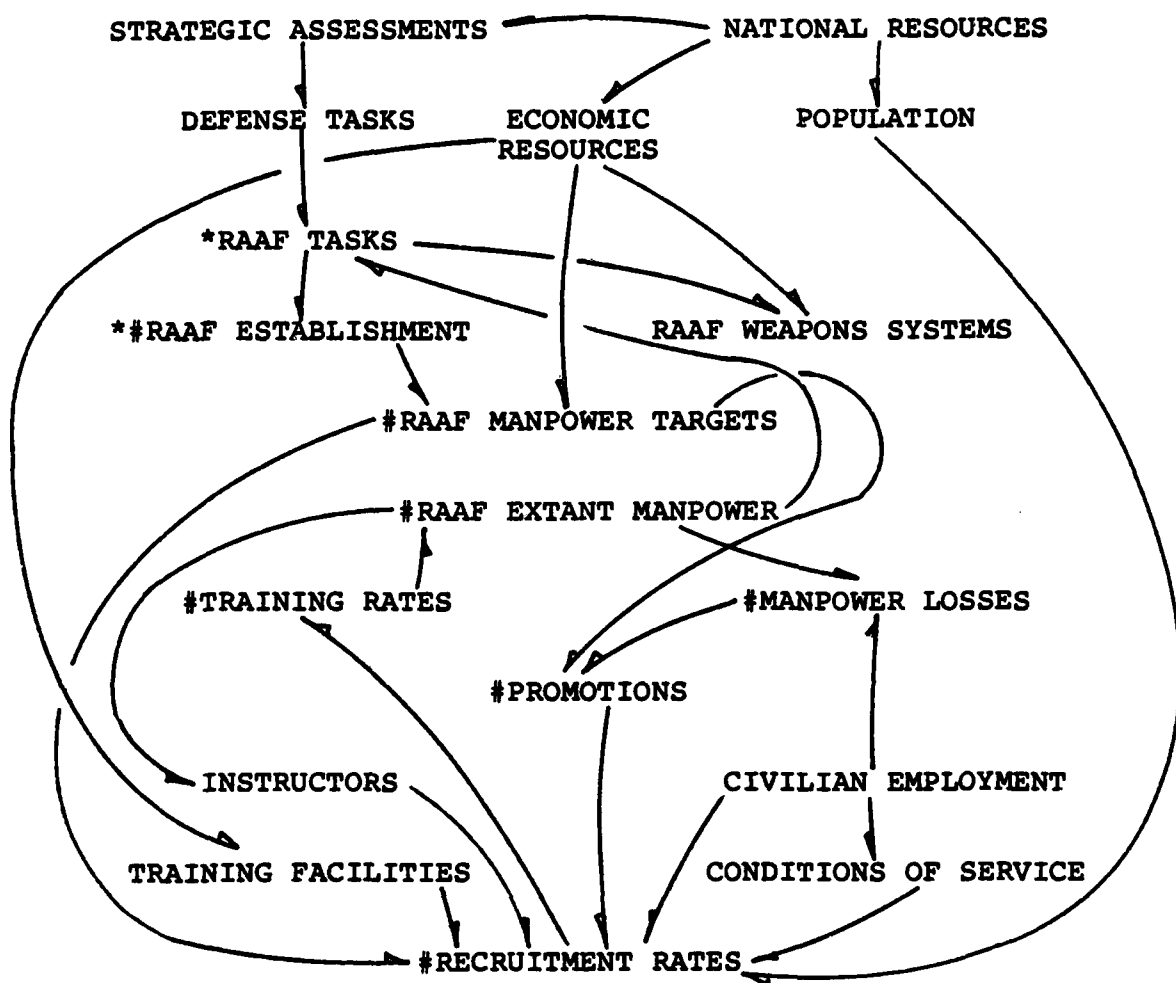


Fig. 1.1 Influence Diagram Showing the Elements that Affect the RAAF Officer Corps

Key: * = Elements of the FORVAR Model
 # = Elements of the ROS Model

interdependent factors in the diagram, and that factors both external and internal to the Service affect the state of the manpower resource. Manpower planning methods must contend with the variety of states that such a complex situation can generate. Consider some (of the many) examples of problems that must be dealt with by the Manpower planner:

1. Many solutions require an expert understanding of human behavior and, although research has been expanding rapidly in this area in recent years, there is often far less than perfect agreement in many relevant areas. For example, theories on methods of achieving the best performance from individuals abound, but there is no single theory that has been demonstrated to be superior (see, for example, Albanese, 1981: 10-13). Thus a manpower resource manager usually cannot be confident that he is using the "one best way" or even that a technique, now thought to be sound, will not be shown to be ineffective by later research.
2. Manpower considerations usually (and rightfully so), lie at the end of a long analytical chain. Threats must be evaluated, force structures determined, weapons developed and, finally, personnel trained to manage and man

those weapons. Reaction to these analyses requires close coordination across many sections of the Service organization as is demonstrated by Figure 1.1. Should any analysis in the chain vary, a change in manpower requirements is likely to follow.

3. Thirdly, the personnel management environment is continually changing. For example, the status of Armed Forces in the USA (and to a lesser degree in Australia), has changed from hero to villain and is perhaps back on its way to hero again. Internally, conditions of service change, while externally, employment rates vary with the state of the economy; the combined effect greatly changes voluntary wastage rates which complicate the management process. The term "wastage" is an important one. In this study, "wastage" means the loss of personnel from the Service due to any cause; e.g., resignation, death, disability, combat losses, and service no longer required. Thus, flexibility must be a key note of manpower management.

Problem Statement

Summary. The effectiveness and efficiency of any Armed Service depends to a great degree on the quality of its personnel, considered to be a valuable resource requiring skilled management. Determination of manpower requirements is a difficult process, complicated by factors such as long lead times, variation in strategic threats, uncertainty about optimum management methods, the requirement for organizational coordination and a continually changing management environment. An incentive to manage the manpower resource efficiently comes from the large proportion of the defense budget that it consumes.

Problem Statement. In essence, the problem is to manage the manpower resource in a way that maximizes the effectiveness and efficiency of the Armed Services. Such management should take account of both long and short term factors, yet remain flexible and adaptable in order to place the minimum possible constraints on strategic plans while consuming as little of the defense resource as possible.

Chapter 2

FUNCTIONS OF A PERSONNEL SYSTEM

Introduction

The purpose of this chapter is to describe manpower management as conducted by the Royal Australian Air Force. Emphasis is placed on a "systems" approach to resource management. Although the Personnel Division of the Royal Australian Air Force has the ultimate responsibility for the disposition of the manpower resource, many other sections of the RAAF have a strong influence over those dispositions, especially on the long term. This "external" (to Personnel Division) control of the manpower resource is as it should be; Personnel Division is essentially a "support" agency which should impose as few constraints as possible on operations. At the same time, it should be clearly understood that to function in the flexible and adaptable manner required, the external agencies must continuously provide timely information (e.g., forecast operational requirements) as an input to the manpower planning process.

"Organization" vs "Systems" Approach. In the previous paragraph, the "systems" approach was mentioned. Some discussion of the difference between "organization"

and "systems" methods may therefore be appropriate. The organization method of solving problems is commonly used in the Armed Services and is based on the principles of bureaucracy as espoused by Max Weber (Albanese, 1981:499). The word "bureaucracy" is not used in the usual derogatory sense; here it implies a relevant and efficient method of organization based on division of labor, a hierarchy of authority, and regulations and procedures covering actions to be taken. Although the bureaucratic method of organization can be effective for many problems facing the services, it is generally too slow and cumbersome for manpower planning activities, primarily because of the requirement for "real time" information from a wide variety of sources. To show the rationale, organizational diagrams of the Royal Australian Air Force higher command, and of the Personnel Division have been included as Figures 2.1 and 2.2 respectively. In the subsequent discussions of manpower resource management methods, it may be useful to identify the various identities on the organization chart and contrast the lines of communication through the hierarchy with the paths on the influence diagram (Figure 1.1) in Chapter 1. This should clearly establish the need for the "systems" approach. This method of dealing with problems is described fully by many authors. A useful reference on this subject is Schoderbek, Schoderbek, and Kefalas (1980). In essence, the systems approach is a method of dealing with the entire

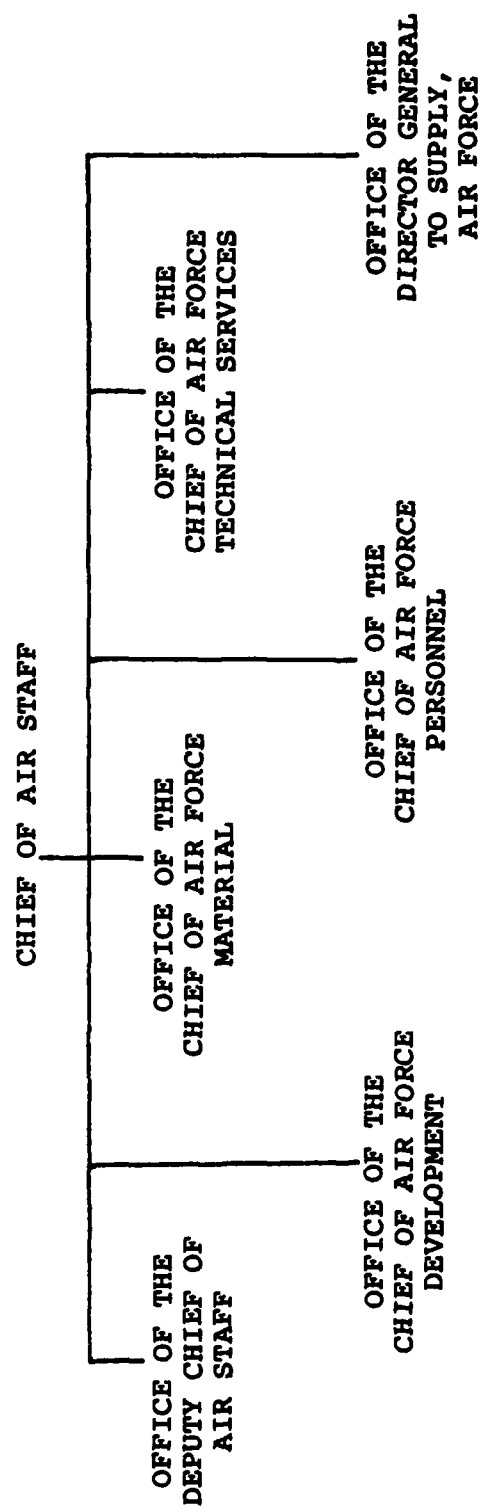


Fig. 2.1 Royal Australian Air Force Higher Organization

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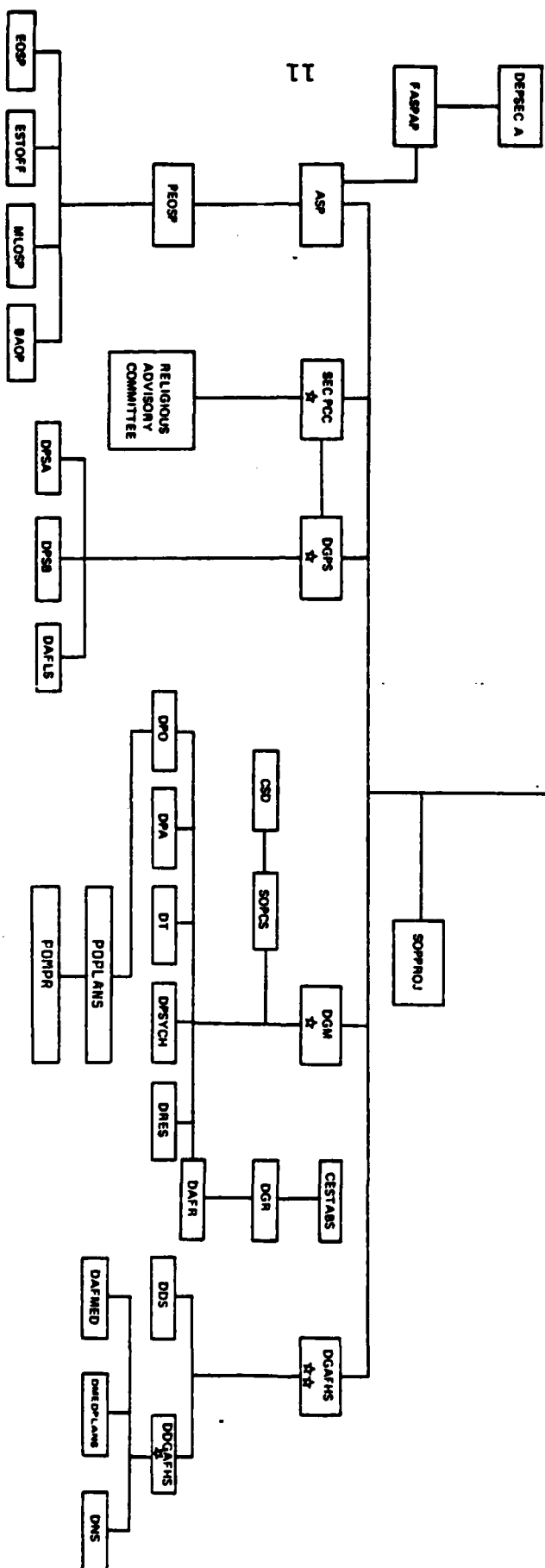


Fig. 2.2 **Organizational Diagram of the Royal Australian Air Force Personnel Division**

problem by taking a "wholistic" view, rather than segmenting the problem as is commonly done in differentiated bureaucracies. Reference to Figure 1.1 shows the elements of the manpower strength management problem. Those elements modeled by ROS are marked with the character "#." Note that the lines of influence cross many organization boundaries and indeed hierarchies. Thus, if the important actions of planning, and control are to be successful, an effective method that can be used is the systems approach, where all the relevant factors are considered simultaneously.

Allocation of Tasks and Resources

From strategic assessments, Defense Force Tasks are determined and resources allocated via a bifurcated system shown in Figure 2.3. The task and resource allocation works as follows. From a strategic assessment, the Australian Government determines Defense Force activities or tasks. These tasks are broken down to tasks for the individual Services. In the Royal Australian Air Force, the Director of Organization and Establishment-Air Force translates these tasks into an organization (e.g., Divisions, Commands, Squadrons and Units), and develops an establishment table, hereafter called the "establishment," containing a list of tasks to be carried out by individual(s). In the case of the Officer Corps Establishment,

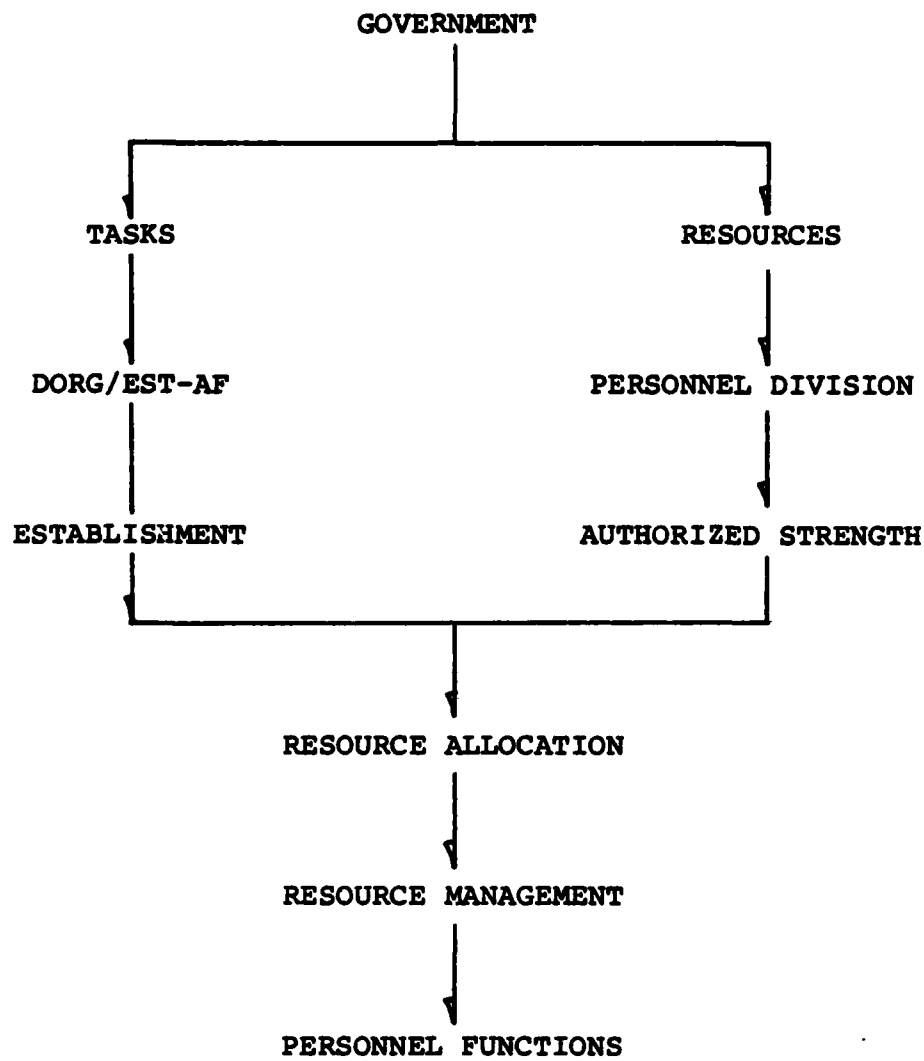


Fig. 2.3 Management of Tasks and Resources

one officer position is assigned to each task. No direct regard is taken of the actual resources available; the process is based on job analyses and a number of manning rules.

The Australian Government also allocates resources to undertake the tasks. Amongst these is the Authorized Terminal Strength which is a manpower ceiling to be achieved at the end of the fiscal year. The Authorized Terminal Strength is broken down by Service, then for the Royal Australian Air Force into officers and airmen and, finally, the officer figure is divided between officer cadets and the "working" officer Authorized Terminal Strength. This last figure is the one of interest in this study.

The disposition of manpower is the responsibility of the Royal Australian Air Force Personnel Division, which must attempt to "man" the Establishment. Regrettably, the resources historically allocated fall about 10 percent short of an Establishment which would satisfy all tasks and, consequently, some positions can never be filled. Thus, allocation rules are required to make most effective use of the authorized manpower. This allocation provides short term targets and the task of strength allocation is undertaken by the manpower requirements cell in the Directorate of Personnel Officers-Air Force. Once strength targets are determined, a continuing activity is the control of recruiting rates to meet these targets. Both long

and short term considerations must be made to build a force of the required structure. Once personnel are available, other sections of the organization control their day-to-day management. These activities are discussed next.

Activities

Structure. This study is concerned with the strength management of the Officer Corps; consequently, only the Royal Australian Air Force officer structure will be discussed in any detail. The Royal Australian Air Force does not use a job classification system similar to the United States Air Force Specialty Code (which is usually referred to as the "AFSC"); instead, officers are recruited into one of twenty-five "Categories" which describe the basic activity of the officer (e.g., PILOT, NURSE, ADMINISTRATIVE). Generally, officers remain within that category for the remainder of their service career. Annual category transfers are less than 1 percent of the total strength. Category strengths range from about 800 for PILOT to as low as six for RADIOGRAPHER. A number of categories are grouped to form five Branches, viz GENERAL DUTIES (the operations Branch), ENGINEER, EQUIPMENT (supply), SPECIAL DUTIES (a variety of categories generally covering support activities), and MEDICAL. Within the Royal Australian Air Force there are nine officer ranks which follow the British

Royal Air Force naming convention; only seven of these ranks are of interest in this study. The ranks are truncated at each end; e.g., Pilot Officers are included with Flying Officers and Air Marshals and above with Air Vice Marshals. The seven ranks and their United States Air Force equivalents are shown in Figure 2.4.

Establishment. The development of the Establishment has been discussed above. The Establishment is recorded by the Establishment Table which contains an entry for each officer position. Copies are held by the Director of Organization and Establishment-Air Force, and the Director of Personnel Officers-Air Force; changes are reported to users as variations to the Table. Numerical summaries are used for strength management. These summaries combine all the individual entries into a number for each rank in each Category. Note that all Categories do not have established positions in each rank; promotion is thus limited in these Categories. Establishment numbers are summarized into Category totals, Branch and Branch/rank totals, and Royal Australian Air Force and Royal Australian Air Force/rank totals. Ideally, changes to accommodate new projects should be issued with at least the lead time required to create officers of the required Category and rank; in practice changes are rarely issued more than a couple of months before the requirement to fill the

a. Flying Officer	= FLGOFF	= Lieutenant
b. Flight Lieutenant	= FLTILT	= Captain
c. Squadron Leader	= SQNLDR	= Major
d. Wing Commander	= WGCDR	= Lieutenant Colonel
e. Group Captain	= GPCAPT	= Colonel
f. Air Commodore	= AIRCDRE	= Brigadier General
g. Air Vice Marshal	= AVM	= Major General

Fig. 2.4 RAAF Ranks and USAF Equivalents

position. Accordingly, other means must be found to estimate the long term changes (see Chapter 4 for an examination of this problem).

Resource Allocation. The Defense Force Authorized Terminal Strength is used as the basis for the Royal Australian Air Force Officer Authorized Terminal Strength as described above. The growth of the Authorized Terminal Strength is based on the Australian Five Year Defence Plan and, compared with establishment figures, is a relatively stable figure. Typically, the officer strength is allowed to grow at about fifty per year which represents an increase of about 1.5 percent per annum. Arbitrary (though realistic) rules are used to divide the Authorized Terminal Strength amongst the Branches, Categories and ranks to form "manning targets." Should changes in the establishment process bring the Establishment closer to the Authorized Terminal Strength, the allocation rules may be changed. Clearly, the ideal situation is a one-for-one match between the Establishment and the Authorized Terminal Strength. The allocation is made each month by the Directorate of Personnel Officers-Air Force strength management cell on the basis of the Establishment at that time. For long range planning, the same allocation rules are used with estimates of the Establishment at the beginning of

each year. (Planning cycles may start at the beginning of the calendar or the financial year.) Allocation rules are:

1. 100 percent manned:
 - a. GENERAL DUTIES Branch,
 - b. Categories with a total establishment less than thirty-five, and
 - c. Ranks above and including Group Captain;
2. 96 percent manned: all Wing Commander ranks not included in subparagraph 1;
92 percent manned: all Squadron Leader ranks not included in subparagraph 1;
3. Variable manning: the remaining portion of the Authorized Terminal Strength not accounted for by these allocation rules is divided among the Flight Lieutenant to Flying Officer ranks not included in subparagraph 1. As the establishment and Authorized Terminal Strength changes, the manning percentage (which equals target divided by the Establishment times 100) will of necessity vary. In recent times, the manning percentage has "floated" between about 88 and 91 percent.

Wastage. The most important factor in creating a Service of a particular quality and structure is wastage.

If wastage could be controlled adequately, for example by selective increases or decreases over the "natural" rate, low quality or surplus officers could be eliminated while high quality officers could be retained. Many personnel policies are aimed at wastage control though often neither the factors causing wastage nor the effectiveness of the controls are well understood. From a numerical point of view, wastage also dominates. In the Royal Australian Air Force, growth is only about 50 per year while in recent years officer wastage has varied between about 220 to 290. Thus wastage has about five times more effect on the Officer Corps structure than growth. Wastage is effected in three ways. A few officers reach age retirement when departure from the Royal Australian Air Force is mandatory. Some (although very few) officers fail to perform sufficiently well after appointment and are not granted permanent status; these officers leave the Service at the end of their short service commission. The majority of officers resign before age retirement, giving three months notice. Many factors affect the timing of resignations; however, by far the strongest correlation is with years of service. This relationship was established by the author during studies that were carried out in his previous job as the Royal Australian Air Force officer responsible for officer strength management (Mills, 1979-81). There are a number of reasons for this relationship; many benefits and return

of service for training are based on whole years of service. The most important is the Defence Force Retirement Benefit Scheme which allows officers with twenty or more years of service to leave the Service with a pension. Finally, within a single year, separation rates are highly seasonal; the greatest cause being high recruiting rates in January and the desire for individuals to complete a whole year of service and/or separate during the school holidays, thereby causing minimum disruption to dependent's schooling. Representation of wastage must take account of these factors; generally the most accurate figures can be obtained by using years of service as a predictor and restricting evaluations of wastage over an integer number of years to avoid seasonal effects.

Promotions. For ranks of Flight Lieutenant and above, the combined effects of growth and wastage create "holes" in the Establishment (or more accurately, "holes" in the targets for each rank in each Category) that must be filled by promotions from junior ranks. In the Royal Australian Air Force, promotions boards are held annually, starting about February and finishing about July. Australian Defence Instruction (Air Force) Pers 5-9, Promotion Policy--Officers (1978), states the criteria for promotion. While there are several criteria, promotions are generally based on merit and seniority, although

regression analysis reveals the major factor is seniority (Mills, 1979-81). Officers must have a minimum time in rank to be considered for promotion in order to allow time to gain the necessary experience as well as allowing time for each officer to be fairly evaluated in his present rank. The number of promotions to the next rank is based on the promotion vacancies which are created by wastage in the rank, growth, and promotion out of the rank. Thus, the promotion process must start at the most senior rank, and successively work down to Flight Lieutenant ("promotion" to Flying Officer is the process of appointment/recruitment). Flying Officers are promoted to Flight Lieutenant on a time basis, the only exception being a failure to complete promotion exams, which is rare. For the ranks of Flight Lieutenant and above, promotion is competitive. Some officers, about 15 percent of the strength in each rank, are considered "unpromotable" and continue to serve in the same rank until they resign or are forced by age to retire. Promotions take effect in "batches" on 1 January and 1 July, with sufficient numbers being promoted on these dates such that the average number in the rank during the year equals the target. At times there are insufficient officers with the required time in rank and/or quality to meet promotion targets. In this instance the promotion board selects those who meet the criteria and promotions will fall short of the target. When wastage is

high or establishment growth excessive, such shortages may become chronic. Nevertheless, the current policy within Personnel Division is to maintain a standard and consequently suffer shortages in the rank, rather than demean the rank by promoting inexperienced and/or inferior personnel. For the GENERAL DUTIES and ENGINEER Branches, promotions are made by Branch, in other instances by Category. However, examination of the promotion rates within these two Branches shows that promotion rates within their component Categories are made at an equitable rate; i.e., there is no policy to discriminate against any Category (Mills, 1979-81). Finally, when a group of officers are promoted, they retain the seniority order they held in their previous rank. The promotion system has developed heuristically over the years, and comments on the factors relevant to promotion are based as much on recent observation as formal documentation.

Recruitment and Officer Training. Growth and wastage deplete the number in any Category below the calculated target. Such shortfalls can only be made up by new officer appointments (given an insignificant level of lateral recruiting (see Chapter 1 for an explanation of lateral recruiting)). Two basic avenues of entry exist. The first is via an officer cadetship where individuals undertake various forms of training (e.g., a Science or

Engineering Degree, pilot or navigator training). The second is via direct entry; mature age recruits (i.e., those whose age on appointment exceeds twenty-one) join directly to become junior officers. Lead time from the awareness of a requirement to appointment varies from about one year for direct entry officers to about five years for officer cadets who complete four-year degrees. A small number of airmen (about thirty-five per year) are commissioned from the ranks. Length of service is calculated from the time an individual enlists (as a cadet or an airman) or is appointed (as a direct entry officer). Accordingly, the number of years of service on appointment can vary from zero to about twenty; generally, though, a representative value can be selected for each Category. Recruiting shortfalls can (and often do) occur when facilities limit intake or insufficient members of the public volunteer to join a Category. Both problems are serious; creating new facilities can take over five years while attempts to persuade more members of the public to join a particular Category (e.g., via increased advertising) are often ineffective. Lowering standards in order to achieve strength targets in the short term has generally been found to be an unsatisfactory practice. The Royal Australian Air Force has a long history of validating entrance standards with subsequent performance; reducing qualifying levels often replaces short term deficiencies with serious long term

problems. Consequently, long term shortfalls in recruiting targets can (and do) occur. The various aspects of recruiting were closely studied by the author during his tour in the Director of Personnel Officers-Air Force, as a detailed understanding of the recruiting process and its constraints and vital to long term strength management (Mills, 1979-81).

Other Activities. Several other activities are undertaken by the Royal Australian Air Force Personnel Division. Perhaps the most important is the "posting" or movement of officers to fill vacancies caused by promotion, growth and wastage. As well as posting activities, development of individual officers (career management) is also undertaken by Director of Personnel Officers-Air Force, by selecting specific officers for training or positions which will provide skills to enhance career progression. Performance evaluation to support promotion and career development is an integral part of the management. Similar activities to Director of Personnel Officers-Air Force are conducted by the Director of Personnel Airmen. Budgeting and Costing is conducted by a civilian cell. Conditions of Service (e.g., policy on pay, leave, allowances, removals, etc.) are monitored by the Director General of Personnel Services-Air Force and is a joint responsibility of a combined Civilian/Serviceman group. Training policy is set by the

Director of Training-Air Force while validation of entrance tests and the performance evaluation is conducted by Director of Psychology-Air Force. With the exception of the costing activities, these activities are not directly relevant to this study, and are only mentioned for the sake of completeness.

Strength Management. This activity is mentioned last as it is the coordinating activity for the majority of the foregoing. Personnel Officers Manpower Planning Requirements is a cell in the Personnel Officers Plans section that accepts a variety of inputs from various sources and integrates data to provide information to interested users, both within and outside Personnel Division. The Establishment is summarized by rank, Branch, Category and, for the Royal Australian Air Force, targets are determined from the Authorized Terminal Strength, wastage data is evaluated, promotion vacancies calculated, and recruiting requirements estimated. The information is displayed on "operations room" type wall displays and regular reports are dispatched. The cell provides staff rather than command advice. A few of the activities are automated via desk-top computers; however, the long range planning (over five years) is virtually impossible by manual methods because of the large number of variables requiring simultaneous consideration. In recent times,

computer assistance has been sought to assist this planning function. This study develops one of the models used in the planning process. A full description of the model begins in Chapter 4.

Experience of the Author. A few words on the author's background may be appropriate at this point. From January 1979 to May 1981, the author worked in the Directorate of Personnel Officers-Air Force. On arrival, there was no standard, well defined method of strength management, and the control of Officer Corps strength was suffering as a result. As a direct consequence, the author was assigned the task of developing a strength management system from "scratch." At this time, there were no data bases specifically designed for this function, nor were the methods of strength management defined. To overcome these limitations, a considerable amount of scientifically based investigative work was conducted, because effective strength management requires a detailed knowledge of the workings of the Royal Australian Air Force Personnel Division, as well as other parts of the Australian Department of Defence. These studies were documented on internal Royal Australian Air Force files and are not publically available. However, when relevant, the author will identify such work with the reference "Mills, 1979-81," as already shown.

Chapter 3

LITERATURE REVIEW

Introduction

In this chapter a brief literature review is reported. The purpose of the review is to compare the Royal Australian Air Force (RAAF) Officer Structure (ROS) model with similar work being done in other areas, if indeed any such work has been completed. Completing this exercise allows an evaluation of the worth of seeking advice from other people working in the area, with the object of improving the model without "reinventing the wheel" or, alternatively, if the ROS model is considered to be in advance of work done elsewhere, being in a position to offer advice, if requested. Two areas of interest were researched--activity in the military and civilian personnel management fields--and each of these studies will be reported on separately.

Before proceeding with the review, it may be appropriate to provide a very brief description of the ROS model so that this description may be held in mind when other work is being described. The description is as follows:

The Royal Australian Air Force (RAAF) Officer Structure Model (ROS) is a computer simulation of the RAAF Personnel Division management of the Officer Corps. The purpose of the model is to provide RAAF planners with a tool to develop personnel plans and policy to support RAAF operations. Given the long lead time needed to recruit and train personnel for particular tasks, plus the large number of variables that impinge on personnel management, providing computer assistance greatly reduces the work load needed to develop plans, and integrates the experience of RAAF experts from the diverse areas that affect the structure of the Officer Corps.

The model is sensitive to strategic demands for manpower via the establishment of officer positions that may vary over time. The RAAF Officer Corps is divided into Branches and Categories of officers, and each Category is represented in the model. Starting with a data base of the present Officer Corps, the model projects the Corps into the future by simulating the activities of the Personnel Division via the policy and rules that govern strength management. All significant activities are modeled, including attrition of officers, growth of Categories, promotion from one rank to the next, and recruiting as constrained by training and other limits. Comprehensive report generation on the structure of the model during the simulation is included, and the model is designed to run interactively, to allow the operator to have some dynamic control over the progress of the simulation. The model may be used to project the Officer Corps for as many years as desired, ten years is a practical maximum. The simulation is written in FORTRAN 77, and runs on a minicomputer.

A particular strength of the model is that every officer in the Service is modeled, and the simulation treats these officers in the same way as does the RAAF Personnel Division. Thus, assuming the data supplied to the model is accurate, the projections, at least for the first few years of the simulation, should show high correspondence with the "real world" events. Every attempt has been made to produce this element of "isomorphism" in the model so that translation of results into plans is not required. Some of the model reports are in the identical format to those used in the manual system, further reducing the requirement of planning personnel to interpret the results [Comments of Author].

Military Manpower Planning Models

To identify models similar to ROS, a Defense Logistics Studies Information Exchange (DLSIE) search was undertaken, using the search keywords relevant to the activity and purpose of the ROS model. A surprising number of models appeared in the information retrieval, some 105 in the first search, and 38 in the second, with only a few models appearing in both searches. Rather than attempt to make comments on each of the models, only those models which are similar to the ROS model will be discussed. The extract from the DLSIE report will be reproduced, then comments made on the model and, finally, summary comments will be made.

Department of the Navy "CEPASS" Model. The CEPASS, "Civil Engineer Corps Projected Annual Strength Simulation" model has the following function:

The CEPASS program computes the predicted number of CEC officers on active duty for a period up to ten years in the future. The predicted number is based on the beginning number as modified by promotion, recruitment, transfer, retirement policies, statutory policies, and expected voluntary attrition. An individual file which contains the grade, promotion status, source, designator, date of birth, date of rank, active duty date, and active commissioned base date is maintained on each officer. Therefore, in any year, it is possible to compute summary totals of officers by grade, number of years of active service, number of years of commissioned service, time in grade, source, and designator. Summaries of annual attrition are also made for each category. . . . The CEC Detail Office of the Bureau of Naval Personnel develops the plan for CEC officers. When the plan is

developed using hand calculations, considerable labor is required, and the evaluation of alternate programs for the procurement, promotion, and retention is limited because of time-consuming computational requirements [Department of the Navy, 1981].

From this description, it would appear that the CEPASS model is very similar to the ROS model with the exception that CEPASS only deals with one section of the Navy Officer Corps, and the response of the model to changing strategic inputs is not defined.

Department of the Navy "CIOM" Model. The CIOM or "Computerized Input/Output Model" is included in this review because of its similar nature to the RAAF Force Variation Model, FORVAR, a strategic planning model used to provide strategic guidance for input to the ROS model. The function of CIOM is:

This computerized input/output model user's manual documents a series of interactive computer routines that permit the assessment of the impact of changes of fleet structure on shore support activities' work load levels. CIOM has three major segments of analytical routines: final demand (modification, computation, and documentation); a linear program solution; and report generation. Emphasis is placed on final demand because it is the vehicle for changing fleet characteristics (size, mix, operating tempo) and testing scenarios based on these changes. CIOM was designed in a totally conversational mode to facilitate modifications and to minimize the knowledge of computer systems required by the user [Department of the Navy, 1982].

This description indicated that CIOM and FORVAR have very similar functions, although no linkages between CIOM and

other models are indicated, as is the case between FORVAR and ROS.

Department of the Air Force Model "TOPLINE". A description of the TOPLINE or "Total Officer Personnel Objective Structure for the Line Officer Force" shows that it has the following function:

The TOPLINE static flow model produces counts of officers classified by component (Air Force Academy, Contract, Regular, Reserve), rating, grade, and year of service, as well as tables of "career flow" that allow one to see the flows into and out of each grade by year resulting from promotion, augmentation, and retirement. The TOPLINE model assumes that the number of officers in each classification and the flows between the classifications remain constant from year to year. Input variables include yearly inputs of Academy graduates and contract officers, retention rates, parameters describing the promotion process, and totals of officers, regular officers, pilots, and navigators. The RAND version presented here was derived from the Air Force's original; however, with some modifications, such as changes in mathematical techniques employed and the addition of the new section on "career flow," have been made. This report describes the mathematical structure of the model and its inputs and outputs. It also describes the RAND FORTRAN version [Department of the Air Force, 1977b].

From this description, it would appear that the model runs in the reverse direction of the ROS model, in the sense that inputs are provided and the outputs produced, rather than in the ROS model, where the model generates its own inputs in accordance with strategically generated demands. A second difference is that TOPLINE classifies officers by component (e.g., regular, contract) rather than by function as is done in the ROS simulation.

Department of the Air Force Constrained Officer
Force Progression Model. This model is described as
follows:

The model is one of a set of computer based models designed to provide personnel planners with broadly based aggregated data and detailed officer inventories and flows reflecting the effects of policies and conditions under investigation. Air Force personnel planners often face policy alternatives that lead to changes in the size of the officer force, the rated officer force, accessions, training rates, loss rates, promotion policies, or augmentation opportunities. When the planner inputs these alternatives into the constraints model, the model then estimates the effects of these changes on the number of officers who are lost, promoted, augmented, or who are otherwise changing from one state to another. The report presents several highly simplified numerical examples and compares this model with other models in the set.

Seven types of data are required by the constraints model, the first five of which--accessions, promotion parameters, loss, rating transfer, and augmentation rates--are almost identical to the progression model's inputs. Two additional types of input data are required by the constraints model: manpower data--manpower requirements that can be imposed on the officer force (i.e., the total size of the officer force; the wartime pilot and navigator requirements; and the desired size of the regular force); and career reserve requirements data.

The constraints model produces several types of output reports that present the officer structure and flows between officer states from both a very detailed and highly aggregated perspective. In addition, if requested by the user, the model prints the results of each iteration whenever iterative model logic is involved, as well as a record of adjusted loss, rating transfer, and augmentation rates [Department of the Air Force, 1977a].

This model seems very similar in scope and use to the ROS model.

Department of the Navy OPM Model. The Navy OPM or "Officer Projection Model" seems to be more general than the Navy models described above, with a function similar to the Air Force model described in the previous paragraph and the RAAF ROS model. Of all the model descriptions retrieved by the DLSIE search, the OPM model seems to be the most similar to the ROS model. The DLSIE description follows:

The officer projection model (OPM) projects the flow of officers through the ranks of the US Navy. It projects an initial officer inventory (characterized by length of service, grade, and promotion status) in yearly increments, accounting for attrition, promotion, legal constraints (Title 10 of the U.S. Code), and such management policies as minimum accession requirements and end strength targets. It is devoted especially to simulating the Navy's officer promotion system, and provides several options which consider the interactions of flow point, promotion rate zone size, grade structure and end strength, and early and late selection. The OPM will also compute annual compensation, separation pay, retirement pay, and the present value of retirement pay for the remaining life expectancy of projected retirees. The model provides management with a tool for evaluating alternative promotion policies and retirement proposals, and for studying the interactions of officer end strengths, promotions, and accessions, and the cost of changes in longevity and grade structure. The users guide, Volume I, describes the Navy's officer system and the model and discusses the data and policy variables to be specified by the user. Volume II, the programmers guide, provides a detailed explanation of the computer coding as an aid to changing, and making special adaptations to the model [Department of the Navy, 1977].

Conclusions. Only a few of the models retrieved by the DLSIE search have been described here, although those that have been described are the only ones which have

a reasonable degree of similarity to either the RAAF FORVAR or ROS models. However, the large number of models described shows that the U.S. Armed Services are very active in the modeling field, with the U.S. Navy probably being the most active. Generally, the models seem to focus on some (relatively small) aspect of the personnel resource management problem; only a few of the models provide a comprehensive overview similar to that provided by the RAAF ROS model. Nevertheless, much similar work is being done, and possibly some benefit would be gained by the information interchange facility offered by DLSIE, or by exchange of personnel in the modeling communities.

Civilian Manpower Planning Models

In order to evaluate the civilian use of simulation models for manpower planning, the appropriate journals were selected for relevant articles. This work produced a surprising result. The DLSIE search of military organizations produced descriptions of far more manpower models than the author expected. In complete contrast, only one article was found which described any use of a simulation model for actual manpower planning, despite searches back to the early 1960s. Subsequently, the decision was made to extract articles that at least showed an awareness of the same problems expressed by the military planners; namely, that manpower is a valuable

resource, affected by many variables, and that requires careful, long-range planning if manpower resource crises are to be avoided. Even with this expanded search criteria, little directly relevant literature on the subject was found, as the subsequent reviews show. As a comment, contemporary civilian literature seems to concentrate on the manager's relationship to his workplace, and his consequent behavior, rather than treating manpower as a "macro" resource which can be managed using techniques found in other fields of endeavor. Examples of those few articles that meet the review criteria are presented below.

"Towards a Stochastic Model of Managerial Careers,"
Vroom and MacCrimmon, 1966. This article is included to demonstrate some of the (relatively) early thinking on the subject of manpower planning. The focus of the article is on the movement of managers from one position or "state" to another. Such movements may be to different jobs at the same level, promotions, or an exit from the organization. The authors make two assumptions about the movements; firstly, the probability of movement from one state to another can be measured from past events with this probability remaining constant, and that the probability of a change of state only depends on the current state. Making these two assumptions is very convenient, since it allows

a Markov analysis to be made. For a discussion of Markov analysis techniques, see Burnick et al. (1977). The method creates a matrix of probabilities of movement from one state to each other state represented in the model, and with matrix manipulation techniques, the probability of movement from the present state to some other state after a given period of time can be calculated. A slight extension of the method allows the estimation of the number needed to maintain the strength of a group represented in the model, hence the potential for use in manpower planning. The method is simple and straightforward and would provide a convenient method of planning if the basic assumptions hold. Regretably, they do not. Firstly, the probability of moving from one state to another depends on many factors which usually change over time. An example in a civilian organization would be a change in economic conditions; such changes can greatly change the probability of promotion or exit. Secondly, the assumption that previous states are irrelevant may not hold. An example would be promotion of personnel based on the breadth of experience; here, job history could change promotion probability. An assessment of this technique for manpower planning is that it is not useful, since it is too simplistic and does not take account of the dynamic nature of organizations. The article does, though,

show an awareness that analytical methods can be useful to assist manpower planning.

"A Model for Understanding Management Manpower: Forecasting and Planning," Deckard and Lessey, 1975. In this article, the authors identify the purpose of manpower as being a tool to assist the organization to achieve its goals through management of the manpower resource. The elements needed to create this tool are then described. The first steps are to identify linkages that affect the demand for and supply of manpower. Next, uncontrolled and controlled variables are separated. Finally, a simple control system is proposed. Incorporated in the control system are the functions of manpower forecasting and manpower planning. Although this article should be classified as theoretical rather than practical, since the article proposes a method of manpower resource management rather than describes work actually done, it is interesting in that it identifies the main elements that must be considered before a useful working model can be constructed. Perhaps the value to be gained from this article is an understanding that both military and civilian manpower resource management rests on the same theoretical basis.

"Computer Simulation: A Training Tool for Manpower Managers," Mahoney and Milkovich, 1975. A quotation from this article may be of interest. The authors state:

Manpower planning appears to be one of the newest and most rapidly growing topics in personnel planning. . . . While manpower planning is a much used term, it is not well understood or appropriately applied. . . . Subsequently, most managers tend to develop personnel policies and make personnel decisions related to separate functional areas, thus overlooking the essential inter-relatedness of these personnel decisions to the firm's profit and other goals. . . . Concepts of system models and system analysis suggest a way of developing an integrated framework for the analysis of manpower and management decisions. . . . Systems models specifying the essential components and inter-relationships permit one to analyze key elements of the system and to analyze the interaction among these elements and the decision making objectives.

The authors then proceed to describe a computer simulation of a personnel system developed to be used as a training aid. Both students and professional personnel managers have used the simulation with, the authors claim, positive results. They suggest the simulation could be also used to evaluate testing analytical techniques such as manpower forecasting, cost analyses, and operations research decision models. Curiously, they do not suggest the use of the model as part of the "real" manpower resource management system. However, the article shows that some simulation work has been done, and the *raison d'etre* quoted above shows a clear understanding of the planning and control issues in the problem of manpower resource management.

"How One Company Manages its Human Resources,"
Bright, 1976. In this final article of the review of civilian manpower resource management methods, the method

used by the Union Oil Company to manage the careers of its top executives is described. The author makes the point early in the article, that until quite recently, human resource planning was considered to be relatively unimportant, but after a number of crises, new methods aimed at eliminating such costly situations were introduced. He also reports that the company attempted to find a solution to their problems but were unsuccessful because of the paucity of work being done in the area. Bright identifies five necessary elements of the human resource management system: access to data, a way to look into the future, estimating future recruiting needs, succession planning, and translation of output per employee into operating goals. A number of computer programs designed to fulfill these needs are identified. The author summarizes the use of the models as follows:

Used independently, these five instruments of human resource planning supplied useful information to the management and staff of Union Oil's departments and divisions. When they saw major storm signals, it was possible to get an audience with the executive committee, one that usually resulted in appropriate remedial action.

Human resource planning did not begin to approach its optimal impact upon the organization, however, until it came to be thought of as another dimension of corporate planning.

This statement, plus the preceding description, shows that the Union Oil Company has a sound understanding of the value of manpower resource management and uses a

number of simulation models to achieve the desired level of control. It is not clear from the article whether a comprehensive model such as ROS is used.

Conclusions

The most striking issue in the literature review is the tremendous disparity in manpower resource management (as assisted by a comprehensive computer simulation) between the military and civilian communities. Such modeling in the military is well advanced, and many of the models are essentially similar, despite the geographic distance between the developers (e.g., the U.S. Navy and RAAF ROS models). Judging from the articles published in the relevant journals, such work in the civilian community is still in its infancy, although the issues seem to be well understood.

One can only speculate on the reasons for this disparity. Perhaps the work is being done, but the lack of a formal reporting system, such as DLSIE, makes the information on this work inaccessible. Given the highly active publication rate in the professional journals, this is not considered likely. A second reason could be that, given a profit motive, civilian organizations consider such work would not be cost effective. However, given the large amount of resources that manpower absorbs, this explanation is also considered unlikely.

The author's opinion about the difference is as follows. The Armed Services are "high technology" organizations, and computer simulation techniques have been used for many years (e.g., in weapons development). Given the technology, many analysts in the Services realized that simulation techniques are applicable to many classes of problems, manpower resource management being one of them. This transfer of technology was certainly a factor in the development of the RAAF ROS model (see Chapter 5). Furthermore, the rules governing changes of state that can affect an individual in the Services are often well defined (e.g., by orders or regulations) which simplifies model construction. Finally, the Services are usually large in comparison with most companies, thus investment in modeling, which can be quite expensive, can be justified on the basis of the number of personnel to be managed with the aid of the model.

The evaluation of the author, based on the literature reviewed, is that the military is several years ahead of the civilian community in the use of computer models which are tools in the manpower resource management process. However, there are signs of a growing awareness in the civilian community of the issues of, and techniques for, manpower resource management. When these necessary factors become more developed, more widespread use of computer simulations as a tool to human resource management can be expected.

Chapter 4

COMPUTER ASSISTED STRENGTH MANAGEMENT

Introduction

In Chapter 2, the functioning of the Royal Australian Air Force (RAAF) personnel system (as pertaining to strength management) was described. The picture that emerges is a complex, multivariate problem requiring a systematic solution with inputs from many parts of the organization, both internal and external to the Personnel Division.

One of the problems outlined was a shortfall of manpower below that required to complete all assigned tasks. As a direct consequence, manpower saving techniques are used wherever possible throughout the Royal Australian Air Force. Examples are extensive use of computers in the personnel, supply and maintenance activities of the Air Force. Personnel Division was the first element of the Royal Australian Air Force to introduce comprehensive manpower saving techniques, introducing a computerized personnel and pay system. (In fact, this was the first such system in Australia, being introduced in late 1963.) As a result of shortages of manpower, only essential tasks are undertaken and, as is often the case

in such situations, often the day-to-day crises are serviced at the expense of long term planning. Regrettably, such an approach can lead to an increased number of crises at a later time, requiring even more manpower. This approach to management can become a vicious circle and once begun is difficult to break.

One solution is to greatly reduce the time needed for long range planning. Much of the planning requires large amounts of tedious (if simple) arithmetic. Consequently, the computational burden can be greatly eased by automating the planning process. This is the approach that has been taken in recent years. Computer models and simulations have been developed to assist the planning process. Such assistance now allows planners to develop plans in a way that could not have been contemplated using manual methods. For example, the process of calculating targets from the Authorized Terminal Strength described previously takes two people about four hours to complete accurately; the computer implementation of the RAAF Officer Structure model mentioned in the next paragraph only takes a few seconds to compute and print the allocation table.

The Royal Australian Air Force is now using two models to assist planning. Both are written in the computer language FORTRAN, as specific requirements for each precludes the use of a simulation language. The models, RAAF Force Variation Model (FORVAR from FORCE VARIATION),

and ROS (RAAF Officer Structure), are used in a hierarchy; the RAAF Force Variation Model is used as a "macro" model to examine changes in the strategic situation while the RAAF Officer Structure Model ROS is a "micro" model which takes the output of FORVAR and determines whether the changes demanded by the model are feasible, given present and anticipated states of the Officer Corps.

Caveat. Before describing the models in some detail, an important caveat should be recorded. Most organizations (at least those that survive) are faced with a continually changing environment and, consequently, most continually change to adapt to the new environment. Often, then, current procedures are based on a combination of past methods and new methods introduced to meet new problems; completely scrapping old procedures and introducing new ones is the exception rather than the rule. A good model should reflect the current procedures; however, the analyst responsible for the model must be ready to adapt the model to make changes as the parent organization adapts to its changing environment. In this study, every attempt has been made to produce a model of the Royal Australian Air Force Officer Corps that exactly mirrors the actual processes that take place in the personnel division. The present model has been developed iteratively towards this goal. At the opening paragraph of the

study, the RAAF Officer Structure model was described as being "isomorphic," meaning "of like or identical form [Schoderbek, Schoderbek, and Kefalas, 1981:31]." The caveat that arises from this discussion is that the models are only relevant while they are maintained to retain the "isomorphic" characteristic. The corollary that follows is that continuous maintenance of both the data input and the simulation code is required if the models are to retain their usefulness.

RAAF Force Variation Model (FORVAR)

FORVAR is an "input-output" model designed to determine changes in manpower requirements resulting from a change in operational requirements. The description of the model is contained in Hole, Pringle, and Smith (1979). For example, if the strategic assessment calls for a doubling of maritime air patrols, the change in manpower in the front line maritime squadrons could be determined by Director of Organization and Establishment-Air Force and operational personnel. A typical change could be that a doubling of patrol time could (say) require an increase in manpower by a factor of about 1.6 in the maritime squadrons.

The difficulty that arises from this situation is that the consequent effects on the support units are difficult to determine. FORVAR copes with this problem by

using matrix manipulation methods to determine the effects of a size change of an "operational" or "front line" unit. An $N \times N$ matrix of N units is constructed in which each unit is represented by one row and column. Across each row, the fraction of support each unit gives each other unit of the RAAF is recorded. (Support for external agencies such as the other Services, Civil Defence, etc. is also recorded.) Self support is included at the intersection of the unit's row and column. Using matrix manipulation techniques, a change in strength of an operational unit can be made to "ripple" through the system, making changes to each other unit that supports it. As, say, a unit that supports a maritime squadron is changed, the units that support that unit are in turn changed. Although the changes may appear to be an infinite series, matrix manipulation allows the changes to be determined in a single step. The final result is a sequence of factors to multiply each unit by to get the required change resulting from the variation in size of the operational unit. A full description of this technique is contained in the above reference to FORVAR.

FORVAR contains a second table which records the number of personnel in each Officer Category and Airman Mustering for each unit in the Royal Australian Air Force. (A "Mustering" is a description of a group of airmen who have similar skills, e.g., "Instrument Fitter.") The

elements of this table are multiplied by the factor determined in the step above. New numbers in each Category and Mustering can now be totaled. Subtraction of the original numbers yields the net change for each Category and Mustering.

Validation is always an important aspect of models such as FORVAR. Provided the total manpower change is restricted to 15 to 20 percent of the present RAAF strength, the model gives a realistic guide to the effects of a change to an operational unit. Beyond this range, economies of scale and possible requirements for a different organization may reduce the accuracy of the model. The "useable range" of the model is still in doubt; since the latest version of the model has been introduced, the Royal Australian Air Force has not undergone any substantial strength changes and, consequently, the opportunity to validate the model against "real world" data has been denied. The validations carried out so far are effectively a combination of synthetic validity and construct validity. For a discussion of these validity concepts, see Stone, 1978:51-57.

Although the validity issue has yet to be resolved, runs carried out to date show that the FORVAR model gives a worthwhile "rough cut" approach to planning that seems to be "believable" when viewed by people experienced in the field and that are consequently useable for planning

purposes. Note that the FORVAR model deals with the Royal Australian Air Force tasks to Royal Australian Air Force Establishment links as shown in Figure 1.1. Model predictions can be taken by the Directorate of Organization and Establishment-Air Force personnel and translated into establishment variations for each Category by rank and by time. (Changes in an input-output model are of necessity of the "step" variety and do not give a direct indication of the time required to achieve the change.) These establishment variations can then be passed to the RAAF Officer Structure model for micro examination.

RAAF Officer Structure Model (ROS)

Model Type. ROS is essentially an "accession" model, in that it examines the progress of an officer (each officer, in fact) through the Officer Corps on a year-by-year basis. Since a detailed description of the model is provided in Chapter 5, only a resume is provided here.

The ROS model requires a number of data inputs to function. From the personnel computer data base, initial parameters are obtained for each serving officer and are stored on a computer disk file. Systems data (e.g., wastage rates, maximum recruiting rates, etc.) are retained on another file. A third file contains the present Establishment and Establishment changes for each

year the simulation will run. The person running the model provides (interactively) the Authorized Terminal Strength for each year.

A variety of outputs is available from the model. The Establishment table and Authorized Terminal Strength are combined with actual strength to show both the resource allocation and the actual or expected variation from the manpower targets determined by the allocation rules. Recruiting shortfalls are identified. A number of tabulations of the structure can be made, showing such items as years of service, changes in status of officers, eligibility for promotion, time in rank, etc.

The model runs interactively, with a "man in the loop." This allows the operator at each time step to view the output resulting from the parameters input to the model, then iteratively develop the best subsequent long range plan within the given constraints. Often, manpower changes needed to meet tentative operational goals may be shown to be infeasible.

Iterative Planning

When the ROS model output shows an operational goal to be infeasible, Personnel Division planners should first examine the parameters of the ROS model to determine if a change could eliminate the constraint preventing the operational goal from being achieved. Should this prove to

be the case, formal requests for policy or resource changes can be initiated, with reasons for the change being supported by the model output. If, however, no changes can be made that would allow the operational goal to be reached, Air Staff are then advised that the operational plan is infeasible due to manpower constraints. The operational plan should then be revised by changing either the time span or the scope of the operational change. A new plan can subsequently be developed and tested for feasibility.

The real advantage of this type of planning is that closure on an optimal (and of course feasible) plan can be accomplished in a few days to a few weeks. Such "closed loop" planning is infeasible using manual methods, simply because of the number of calculations involved. The alternative "open loop" manual planning has a far greater risk factor. Although both planning methods can contain error, the "open loop" method does not use all of the available information to make projections into the future, and is thus likely to depart from feasibility much faster than the "closed loop" method. This situation can result in the Service allocating scarce resources to an infeasible plan, then having to abandon the plan at a later stage when infeasibility resulting from an unevaluated constraint on the plan becomes evident. Such changes can lead to considerable waste.

Thesis Task

Both the FORVAR and ROS models are presently being used (although at a fairly "primitive" level) by the Royal Australian Air Force. However, neither model is written in ANSI FORTRAN code and ROS has not been documented. Personnel Division is installing a new computer which will be provided with an ANSI FORTRAN 77 compiler. At present, ROS does not have the capability to compute salary and training costs. Accordingly, the task of this thesis is to:

1. convert the present ROS code to ANSI standard FORTRAN 77 to enhance its portability between computers;
2. provide a capability to produce tables which detail the cost of salaries and training;
3. make minor changes to the code to enhance the usefulness of the model;
4. show the internal validation of the model, and suggest methods for completing external validation; and
5. document the model, including an operations manual which will assist the transfer of the model to a new computer, and the subsequent maintenance of the model as a planning tool.

Chapter 5

RAAF OFFICER STRUCTURE MODEL

Introduction

In this chapter, the Royal Australian Air Force (RAAF) Officer Structure (ROS) model is discussed in detail. Sections of the chapter cover the history of the model, the type of model, how it is operated, the internal functioning of the program, and outputs available from the model.

History

Manpower resource modeling has been undertaken by the Australian Department of Defence for many years. The original interest in simulation modeling was an outgrowth of the Weapons Research Establishment where simulation techniques have been used since the mid 1950s to develop weapons. Staff from this establishment (now called the Defence Research Centre, Salisbury), were part of the Defence Scientific and Technology Organization and filled staff positions when the Central Studies Establishment was formed in Canberra in the early 1970s. Originally part of the Department of Supply, Central Studies Establishment is now part of the Analytical Studies Branch of Defence Science and Technology Organization.

The Australian Army commissioned Central Studies Establishment to develop the first manpower models, and these were completed in the early 1970s. In 1975 the Royal Australian Air Force tasked Central Studies Establishment to develop the RAAF Force Variation model FORVAR to assist strategic studies. The Royal Australian Navy (RAN) in 1979 tasked Central Studies Establishment with developing a model similar to the present RAAF Officer Structure model to assist forecasting officer requirements during an extensive modernization of the fleet.

In January 1979, the author was posted to the planning section of the Directorate of Personnel Officers-Air Force. At the time, there were no formal methods of estimating either immediate or future officer requirements. Furthermore, increasing strength shortfalls below manning targets were becoming evident; the cause was a combination of inadequate strength management methods and high wastage rates. During a reorganization of the Directorate of Personnel Officers-Air Force, the position of Manpower Planning and Requirements (POMPR) was formed to gain a better control over strength management. A wide range of associated studies was conducted (e.g., wastage structure and causes, force structure analysis) and a number of data bases were built (e.g., wastage, strength on particular dates). A manual system of strength management was

developed, using "operations room" displays to facilitate the dissemination of information.

Some simple simulation modeling of the Officer Corps was attempted, using a desk-top computer. Although this exercise was instructive, the models created fell short of meeting forecasting requirements because of irregularities in the structure of the Corps (Mills, 1979-81). The most serious irregularity is the "Vietnam hump," so named because of a high concentration of officers who were recruited during the Vietnam conflict. Large concentrations of strength cause nonlinearities that upset simple models. The detail required a processor larger than a desk-top computer; to allow sufficient speed and size at least a "mini" computer was needed. To provide these capabilities, Central Studies Establishment was asked to develop a model in which each officer was represented. Going to this level of detail was thought necessary to overcome the structural irregularity problem. Examination of the model being used by the Royal Australian Navy revealed that it would be suitable for the Royal Australian Air Force's purpose; furthermore, it could be made to interface with FORVAR, such that the output from FORVAR would become an input to ROS.

Since late 1979, ROS has been continually improved. Considerable reprogramming work was necessary to produce a model that represented the procedures used within the Royal

Australian Air Force, as there are substantial differences between each of the Armed Services of the Australian Defence Forces; e.g., the structure of the Corps, resource allocation, promotion practices, and recruiting. Despite the high programming workload, the basic structure of the extant model saved considerable development time, particularly in the conceptualizing phase. The ROS model was developed iteratively; the Central Studies Establishment analyst/programmer worked closely with the author to make the model match the actual operation of Personnel Division and the Directorate of Organization and Establishment-Air Force, as closely as possible. While manual strength management methods were being developed, the ROS model was evolving in parallel. An acceptable version was demonstrated in April 1981, just before the author's departure to the United States to undertake the Air Force Institute of Technology course. Only brief and draft documentation was completed. Moreover, interest was building in the cost of the Officer Corps; this module was considered the next capability which should be added to the model.

Model Type, Language, and Operating Philosophy

Type. ROS is an isomorphic, discrete, time stepping, "accession" model. Isomorphism has been discussed in Chapter 4; every attempt has been made to have the model process the individual members in the data base in the same

way that the Personnel Division actually processes its officers. (More will be said on the isomorphic properties of the model at the conclusion of the chapter.) Every officer in the Corps is modeled. A time step of one year is used, and during each year an officer may leave the service, be promoted or remain unchanged. The number of time steps is set by the data files; at present the model may be advanced by ten years. New officer recruits are created when necessary. Thus, the model is discrete in both its time step and in the treatment of individuals. The "accession" description comes from the movement of officers; the Service is modeled as a hierarchy of seven ranks from Flying Officer to Air Vice Marshal, with officers moving from the lowest to the highest, but never in reverse.

Choice of Languages. ROS was written in FORTRAN, but the code did not fully comply with American National Standard Institute (ANSI)--1977 FORTRAN standards. FORTRAN was chosen for several reasons. Firstly, the language was readily available and the compiled code would execute rapidly (in comparison to, say, interpreted BASIC). Secondly, FORTRAN was already being used in the source Royal Australian Navy model (thus creating a historic imperative). Thirdly, simulation languages were considered, but rejected, because they were not readily

available on the new Personnel Division computer and did not provide the flexibility to model the often heuristically developed Royal Australian Air Force procedures, nor could they provide the highly formatted and detailed output available in a general purpose language. In addition, simulation languages often have limits that preclude their use on large problems; e.g., ROS has a capacity to model 5000 individuals (in its present form, although this limit could be easily extended), whereas, for example, Q-GERT can only model about 500. (Q-GERT (Queueing Graphical Evaluation and Review Technique) is a network simulation language (Pritsker, 1979).) Finally, well written source code is usually more compact than the code created by a simulation language, leading to much lower execution times.

Simulation Techniques. A variety of simulation techniques is used within the model. Wastage and promotion selection (as opposed to the procedure) are treated stochastically, while most other processes (e.g., the allocation of resources, determination of recruiting requirements) are treated deterministically. The algorithm attempts to model the practices of the promotion board) although there are no documents that detail the promotion procedures, apart from defining eligibility parameters (Australian Defence Instruction (Air Force) Pers 5-9,

Promotion Policy, 1978). Thus, the model can be considered to be a hybrid of several commonly used techniques.

Operation and Programming Philosophy. Every attempt has been made to make the model easy to operate by people who do not have a detailed knowledge of computing techniques. Wherever possible, model data is read in from a file under program control to avoid data entry errors and to reduce the workload on the operator. Some knowledge of the computing system's text editor is required to maintain these data files. Error trapping is used where practical. A "man in the loop" principle is used to allow the operator to iteratively close on a desired solution or, alternatively, use his experience to find a solution to a problem. Thus, some inputs are taken from a terminal to provide flexibility in the runs. The operator can choose to have the output returned to the terminal, or printed on a line printer after the run is over. Finally, and perhaps most importantly, most of the structure is defined by parameters contained in a "systems" file. This allows the structure of the model to be changed to follow changes in the Service, without the requirement to extensively reprogram.

Model Operation Overview

Overview of the Procedures. The operation of the ROS model is shown in Figure 5.1, where the hierarchical

```

START:
  Call the Object Code and make Logical Assignments
  Run Module:
    Select Print Option (Terminal/Line Printer)
    Read Data Files
    Select Option:
      Advance Model
      Print Establishment Table
      Print Costs Table
      Tabulate the Data Base
      Restart from Year 1
      Stop
END

Advance Model:
  Nominate Wastage Factor
  Nominate ATS
  Calculate New Establishment
  Make Strength Allocation
  Determine Wastage
  Select Promotees
  Create Recruits
    Re-allocate Recruiting Shortages
  Age Officers
  Resequence Corps
Return

Print Establishment Table:
  Print Table
Return

Print Costs Table:
  Print Table
Return

Tabulate Data Base:
  Select Tabulation:
    Time in Rank
    Length of Service
    Category
    Branch
    Significant Change Indicator
    Eligibility for Promotion
  Return
  Select Tabulation Confinement
  Select Class Width
  Print Table
  Go To Select Tabulation

Restart from Year 1:
  Re-read Initial Data Base
Return

```

Fig. 5.1 Operation of the RAAF Officer Structure Model

structure of the running is shown as successive indentations. Note that the program is written as a main program that calls a number of subprograms to complete the selected tasks. The main program and each of the subprograms are discussed in detail in the remainder of the chapter.

Invoking the Model

File Structure. The ROS model has four data files, four working files, and of course the program file. A detailed description of the data files can be found in the Operations Manual at Appendix A. The files function as follows:

1. Program File. The FORTRAN object code controls the processor during the simulation.
2. Data Files:
 - a. System Data. This file contains data which could generally be described as structure and constraints. Contents are:
 - Number of Ranks
 - Number of Categories
 - Time Step
 - Initial Year
 - Wastage Factor
 - Number of Branches
 - Branch Names

Significant Change Names

Tabulation Parameters

Years of Service on Recruitment

Minumum Time in Rank

Promotion Probability

Wastage Probability

Maximum Recruits per Category per Year

b. Establishment Data. The Establishment for each Category and rank, plus total establishment and the Category name are contained in the first table. Subsequent tables contain the variation to those tables.

c. Manpower Data. Each officer is represented in the model. The data recorded on each officer is:

Time in Rank

Years of Service

Rank

Category

Branch

Eligibility for Promotion

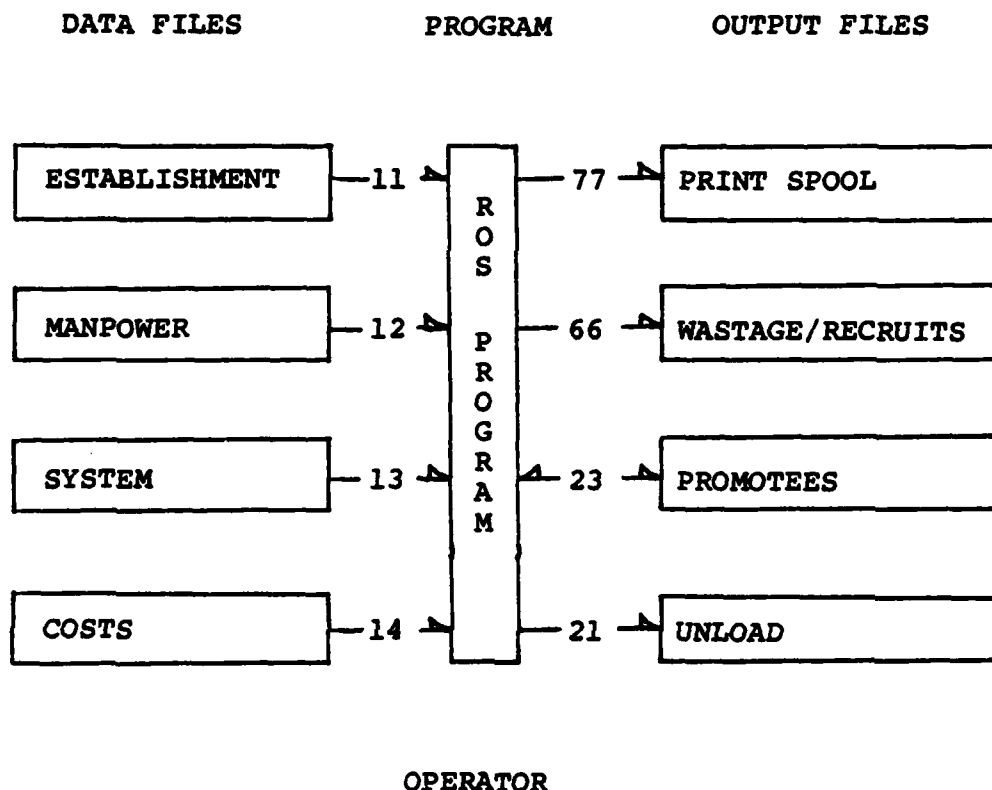
Significant Change Indicator

d. Costs. The recruiting/training cost for each new recruit in each category is included.. Three subsequent tables contain

salary costs for the General Duties Branch, the Doctors and Dentists, and other officers not included in the divisions.

3. Working Files. The four working files are:
 - a. Print Spool. The operator can choose to send the printout from the model on to a spool file for later printing.
 - b. Wastage. Officers who are wasted from the model are written to this file. At present, the information on this file is not used; however, this function is retained to allow future development of the model, and also to assist diagnosis of problems during model development.
 - c. Unload. A file is retained to allow the manpower data base to be "dumped" to assist diagnostics or additional analysis.
 - d. Recruits. This file holds recruits "created" during the advancement of the model. These recruits are subsequently merged with the main data base.

The interaction of the ROS program file, the data files, and the operator is shown in Figure 5.2. FORTRAN requires that logical files be connected prior to the run. Each computer will have a different method of accomplishing this function. In the case of the Harris computer



Key: Data Flow =
: Numbers on the files are FORTRAN logical assignments.

Fig. 5.2 Operation of the ROS Model
Showing Data Flow

system used to run this simulation, a "macro" procedure has been created which, when invoked by the command "RUNROS," automatically makes the required connections, and then starts the object code executing. This macro file is listed in the operations manual at Annex A.

(Note that the operator may amend the macro to have the printout saved on a work file or passed directly to the line printer.) This macro procedure frees the operator from having to make ten separate assignments (eight for the files and two for the terminal), which makes the model very simple to invoke, while eliminating the possibility of error in the process. Most computer operating systems have some method of automatically executing such a stream of commands. More detail on this subject may be found in the Operations Manual at Appendix A.

Main Module Operation

The main program module of the ROS model is quite short, operating by making a series of calls to subprograms elsewhere in the code. The sequence of operations is shown in Figure 5.1; the operator makes the choice to have the printout (of tables) made to the terminal or saved on a print spool file. Only the lengthy tables are spooled to the printer; the normal dialogue required to run the model is passed to and from the terminal. The print spool option can reduce the time for a ten-year simulation from

two to three hours to about twenty minutes; printing tables at the terminal is very slow and thus time-consuming. The wastage factor and Authorized Terminal Strength is nominated for Year 1 of the simulation, and data files are read. During the reading process, an array containing Establishment and actual strength totals is compiled, with values being kept for each Category/rank cell.

The "select option" section is the heart of the model operation: the operator keys in a letter corresponding to the option desired, and the program branches to the necessary function. An explanation of the completion of model functions is in order at this stage. The implication of the above paragraph is that there is a single subroutine for each of the required functions. This is not true in most cases. The program has been written in "modular" form to assist development; however, in many of the functions, several subroutines must be called to complete the required processing. Often, subroutines are called from several other subroutines. Good examples are the subroutines IN and OUT. To fetch the data on each officer quickly, each officer is represented by an element of the array IOCORE. Subroutines OUT and IN change the seven subelements of each IOCORE element into the single variables Time in Rank, Years of Service, Rank, Category, Branch, Eligibility for Promotion, and Significant Change

Indicator and vice versa. This facility makes the source code much more "readable" and offers the opportunity to code the officer data to save memory, should limited memory be a factor in the implementation. When the operator has completed the required simulation runs, the "Q" (quit) option is selected. This stops the program, and the operator is reminded to copy the print spool file to the printer or collect the printed tables.

Advance the Simulation

Establishment Variation. The ROS model is "goal seeking" in that it tries to fill each established position, subject to constraints imposed by the Authorized Terminal Strength, promotion rates and recruiting. On startup, the model reads the Establishment totals for each Category and rank. Note that some Category/Rank combinations may have a zero entry. For each year of the simulation, changes in the Royal Australian Air Force Officer Corps structure may be determined from output from the FORVAR model or as advice from the Director of Organization and Establishment-Air Force as described in Chapter 2. These changes are recorded as variations to each cell of the Category/rank array and are read from the establishment file, and increment/decrement the Category/rank cell totals as appropriate. This process is automatic; it requires no action from the operator other than the "G"

command to advance a year. The data presently in the model allows projections to be made for the next ten years; a more typical projection would be to support the Five Year Defence Plan (FYDP) by making projections for five time periods.

Strength Allocation. While the Establishment defines the Force structure, the Officer Authorized Terminal Strength defines the target strengths to be achieved in each Category/rank cell. These targets are reached by promotion or recruitment. To some degree, the total Royal Australian Air Force Authorized Terminal Strength may be traded between the Officer and the Airman Corps. A typical reason to trade numbers would be an inability to reach targets; in this instance a shortfall in one Corps would be made up in the other Corps to ensure the Royal Australian Air Force made full use of its allocated resources. Because of the flexibility of the Authorized Terminal Strength, this figure is made an input variable and is read from the operator at the beginning of each year of the run. Once the overall Authorized Terminal Strength is given, the program allocates the resource as defined in Chapter 2. Note that the process is not exact; rounding errors can give an error of one or two in the allocation. The algorithm makes two attempts to fully allocate the given Authorized Terminal Strength;

however, an error of one is common but may be disregarded as being insignificant as far as the accuracy of the results of the model is concerned.

Wastage. Wastage has previously been defined as the loss of officers from the Corps, for any reason. The system file contains a 40 x 5 table in which the dimensions represent years of service and Branch, with each element of the array representing the probability that an officer of that number of years of service and Branch will leave the Service. These data are derived from the wastage data base held by POMPR and are obtained from an evaluation of the past two years' records. Wastage rates are subject to general shifts; examples are a general pay increase and a change in economic conditions. Rather than keep a new table for each year, a general change figure is read from the operator at the beginning of each year, and the probabilities in the table are adjusted by this amount; e.g., a drop of 15 percent in wastage would be represented by a wastage factor of 0.85. Once the wastage probabilities have been so determined, the program examines each officer in turn, starting with the most senior. A random number is generated by the computer, and if the number is less than the wastage probability, the officer is deemed "wasted" and his significant change indicator is marked

with the value 4. At the same time, a table of actual strengths is decremented by one.

Promotions. The promotions module proved to be the most difficult to implement, mainly because the actual promotions process has developed heuristically and is not clearly defined by regulations. However, there are some factors in the promotion process that are well defined, allowing a reasonable simulation to be constructed. Firstly, promotion vacancies to each Category/rank cell are simply the target for the year, less the actual strength in the cell, plus the promotions and wastage from the cell. This "promotion target" is calculated during the process of establishment growth, Authorized Terminal Strength allocation, and wastage. Secondly, eligibility for promotion is essentially a minimum time in rank; this figure is held in the systems file and is read into variables when the model is started. Eligibility also depends on the time the person has previously been eligible. If a person has been "passed over" for promotion several times, he may be unpromotable. The Royal Australian Air Force allows these officers to serve in their present rank until resignation or age retirement; they are not forced to leave the Service. ROS models this effect by allowing an officer to remain in the eligible for promotion for five years; if the officer is not promoted after these

five opportunities, he is deemed ineligible for promotion and his data record is marked as such. Note that the method of estimating the "promotion zone" is an artifact of the model and not actual promotion policy. Thirdly, the promotion process is completed in order from Air Commodore rank to Flying Officer rank. This follows promotion board procedure and is necessary to allow calculation of vacancies for promotion. Fourthly, within a Category/rank cell, the officers eligible for promotion are examined in seniority order. A random number is drawn and compared with the promotion parameter read into the "promotion probability" table mentioned above. If the random number is less than the promotion probability, the officer is marked as having been promoted. Again, note that this "promotion probability" method of selecting officers for promotion is a modeling artifact. At present a promotion probability of 0.3 is used for each cell; this figure should be improved by observing (over the past several years) the actual promotion rate of eligible officers in each cell. Fifthly, only Flight Lieutenants, Squadron Leaders, and Wing Commanders compete in this manner for promotion. In the case of senior officers (Group Captains to Air Vice Marshals), the small numbers in each cell do not warrant this complex selection process, and the most senior eligible officer is selected to fill a vacancy. Note that there are no promotions for Air Vice Marshals;

they may only retire from the Service. In the Flying Officer rank, officers are granted "time promotion" if their time in rank exceeds the minimum time in rank, which is a reasonable advancement method as very few officers fail to progress beyond Flying Officer; in the "real world" Flying Officers do not compete for promotion, they only have to complete promotion examinations to be eligible for promotion. As a closing comment on the paragraph on modeling promotions, the observation must be made that this is probably the least satisfactory and most difficult part of personnel procedure. Here, an attempt is being made to model quantitatively, what is literally a qualitative issue. The algorithm may fail to fill promotion vacancies. This situation is common in practice; however, the number of officers promoted depends on the minimum officer quality the promotion board is prepared to accept (as well as vacancies of course). Quality standards are likely to vary with time and pressure to fill vacancies. In effect, this segment of the model must be developed heuristically, with the analyst/modeler juggling promotion probability and promotion zone parameters to reflect current promotion practices, until a sufficiently accurate representation is obtained.

Recruitment. At the conclusion of the strength allocation, wastage, and promotion processes, vacancies

for recruits will be evident at the lowest rank. These are not always filled as there are constraints on recruiting as described in Chapter 4. However, in this instance, the Category Flying Officer strength targets are ignored; if the vacancies exist and recruits are available, they will be included in the data base. The important constraint is based on the minimum of the number who can be recruited, and the number who can be accommodated by the training system. This constraint figure (for each Category) is obtained from the systems data file, and a new figure allows the constraint to be changed to represent changes in training capacity or expected changes in recruiting rates; consequently, some judgement is required to set these figures. The ROS program only limits the number of recruits if this constraint is reached. In the case where strength exceeds target (which could arise if the force was being reduced in size or a Category was being eliminated), the model carries the surplus to the next year, allowing wastage to reduce the excess. In addition to a recruiting constraint, recruits who are accepted join with a predetermined number of years of service. This parameter is read from the systems file on start-up, and a single figure is used in each Category for the time span of the simulation. Manual intervention in the recruiting process is allowed. If the model were allowed to run under these rules, the strength achieved would fall short

of the Authorized Terminal Strength by the sum of the shortages in each Category. The model advises the operator when a shortfall occurs and gives the opportunity to over-recruit. This practice is present in the manual system, where shortfalls in one Category can be made up in another, provided the Category Establishment is not exceeded. To assist the operator, the Establishment/Target/Actual/Balance (ETAB) table may be optionally printed at the terminal for each year (it bypasses the spool file); the operator can then manually distribute the shortfall by nominating a Category number and the number of extra recruits to force on that Category. No checks on the allocations are made by the ROS program during this process; however, the reference to the printed ETAB table and the operator's skill are usually sufficient to make the required allocations.

"Ageing" Each Officer. At the conclusion of the processes of growth, wastage, promotion, and recruitment, it is necessary to make changes that move the model forward in time. Since the representation of the Officer Corps is the accumulation of individual characteristics, the changes to increment time are made to the data on each individual officer in the data base. Firstly, the years of service for each officer are incremented by one. Secondly, time in rank is incremented by a year, unless

the officer has been marked for promotion, when time in rank is set to zero at the new rank. No other changes are required.

Resequencing the Data Base. The ROS model requires the data base to be in the following order: rank decreasing, category increasing, and time in rank decreasing. The reason for this requirement will be apparent from the previous description of the functioning of the model. In particular, promotion selections are made starting with the most senior ranks, and within a rank, with the officers with the greatest time in rank. If the data base were not in the order described above, the model process would not match those of the manual system. At the end of the processing, the data base will be out of order; some officers will still be present although they are to be "wasted" from the simulation while promotees must be moved up a rank, often ahead of officers who are senior. The resequence module restores the required order. To make minimum use of storage space and computer processing time, the program uses a merging technique rather than a sorting technique. The process requires two passes of the data base. In the first pass, promotees are written out onto a temporary file, wasted officers are eliminated, while the remaining officers are "squashed" down to leave room for the merging process. During the second pass,

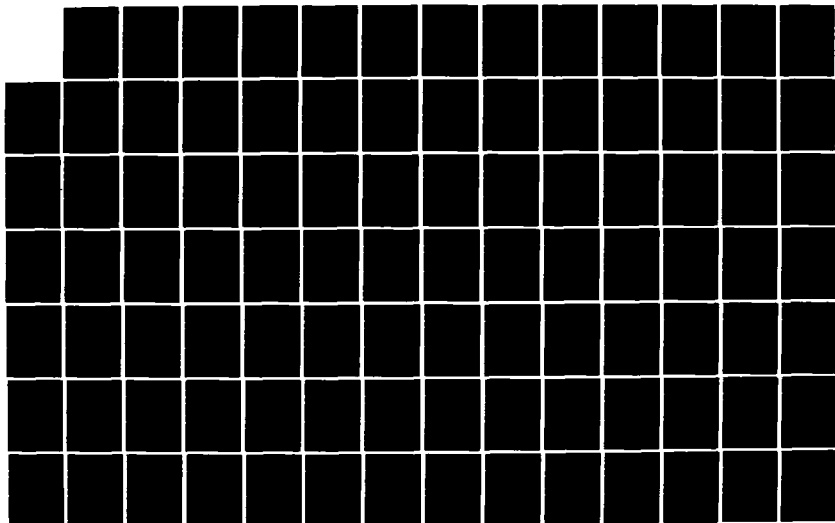
AD-A122 847

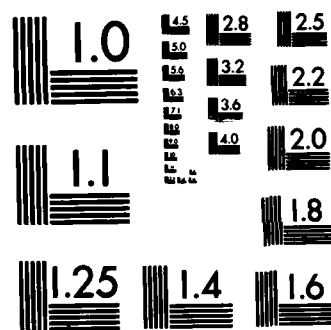
A COMPUTER SIMULATION OF THE STRUCTURE OF THE ROYAL
AUSTRALIAN AIR FORCE. (U) AIR FORCE INST OF TECH
WRIGHT-PATTERSON AFB OH SCHOOL OF SYST. C L MILLS
SEP 82 AFIT-LSSR-15-82 F/G 5/1

2/4

UNCLASSIFIED

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

the two data bases are merged to create the new data base, now in the correct order. When the extant officers have been processed, recruits are "created" and introduced (with zero time in rank and years of service), based on requirements previously determined for each Category and stored in a data array until this process is called. Note that during the promotion process, officers are moved to the new rank in the seniority order they held in the previous rank; this is in accordance with Personnel Division procedures. A second point to note is that, although officers who have wasted from the core are eliminated, their records have been retained on a separate temporary file which can be used for subsequent analysis. Finally, recruits are also written to this file; they may be discriminated from wasted officers by the significant change indicator.

Model Output

Introduction. In many models, a single output is produced. ROS is designed to be a general-purpose model; consequently, a great deal of variety in output is required to absorb the variety of research requests that could be made. This section describes the various outputs that can be produced by ROS, and some examples will be included. Should additional outputs be required to support a specific research project, the data structure of the model is such

OPTIONS ARE: "G", "H=HELP", "Q", "U", "T", "E", "C", "R"

?

G

WHAT IS THE WASTAGE FACTOR FOR THE YEAR 1981

.85

WHAT IS THE ATS FOR 1982 ?

3700

-1 MEN LEFT OVER IN INITIAL ALLOCATION

TOOK ONE BACK FROM FLGOFF EQUIPMENT

0 MEN LEFT OVER IN FINAL ALLOCATION

ATS USED= 3700

THE FOLLOWING SHORTAGES WERE CAUSED BY RECRUITING LIMITS

CATEGORY 2, NAVIGATOR SHORT BY 36

CATEGORY 3, AERONAUTICAL SHORT BY 11

CATEGORY 4, RADIO SHORT BY 24

CATEGORY 5, ARMAMENT SHORT BY 9

CATEGORY 9, WORKS SHORT BY 6

CATEGORY 13, INTELLIGENCE SHORT BY 14

CATEGORY 17, POLICE SHORT BY 1

CATEGORY 19, DOCTOR SHORT BY 18

TOTAL SHORTAGE WAS 119

IN ORDER TO HELP YOU RE-ALLOCATE THE RECRUIT SHORTAGES

I CAN PRINT THE COMPLETE MANNING AND ESTABLISHMENT TABLE

OR I CAN SUPPRESS IT FOR THE REST OF THE RUN.

DO YOU WANT IT? (Y/N)

?

N

HOW DO YOU WANT TO REALLOCATE THE RECRUIT SHORTAGES?

TYPE IN A SERIES OF LINES, EACH LINE CONTAINING TWO NUMBERS,

A CATEGORY NUMBER AND THE NUMBER OF EXTRA RECRUITS TO FORCE

ON THAT CATEGORY.

FINISH WITH TWO ZEROS IE 0 0.

?

8 20

?

10 20

?

0 0

1982

RANK	PLTOFF/ FLGOFF	FLTLT	SQNLDR	WGCDR	GPCAPT	AIRCDR	AVM	TOTAL
STRENGTH	987	1365	747	395	108	32	14	3648
TARGET	1149	1145	824	424	115	31	12	3700
ESTABLISHMENT	1230	1243	879	431	115	31	12	3941

COUNTS OF OFFICERS PROMOTED AND NEW RECRUITS:

PROMOTIONS	0	118	68	58	25	3	1
RECRUITS	228	13	0	0	0	0	0

COUNTS OF OFFICERS EXITING:

RETIRED	0	0	0	0	0	0	0
WASTED	36	86	50	46	18	3	1

Fig. 5.3 Summary of Events for the Previous Year

that the required outputs can be obtained relatively easily.

Summary Report. At the beginning of each year in the simulation, the model produces a summary output. In the first year, the data includes strength, target, and establishment by rank. For each subsequent year, after the officers in the Corps have undergone processing, additional data fields are shown. These are counts of promotions, recruits, retired and wasted officers, again summarized by rank. Figure 5.3 shows an example of this report. In the present model, there will be no counts in the "retired" column as there is no explicit modeling of age retirement. However, if the length of service of officers shows an increasing trend, rather than a decreasing trend as at present, wastage of officers through age retirement could become significant, in which case this section of the model would be developed.

Establishment/Target/Actual/Balance (ETAB) Report. The ETAB report is shown at Figure 5.4. This report can be produced at any time by selecting the "E" (for Establishment) option in the main program. The report is lengthy and takes several minutes to print at a terminal, thus is one of the model outputs that can be sent to the print spool for later production. However, the operator can also elect to have the report automatically printed

STRENGTH AND ESTABLISHMENT LEVELS
FOR ALL LATER-UNITED STATES AIR FORCE
FOR THE YEAR 1963

CATEGORY		PLANE	PILOT	SQUAD	USCIN	OSCAPT	ALSCN	AMN	TOTALS
PILOT	EST/ACT	200/ 219	197/ 275	140/ 140	115/115	41/ 41	16/17	7/ 9	825/ 825
	TARG/BAL	200/ -81	197/ 76	140/ 0	115/ 0	41/ 0	16/ 1	7/ 2	825/ 0
NAVIGATOR	EST/ACT	147/ 100	109/ 118	50/ 65	54/ 43	10/ 14	4/ 5	2/ 2	392/ 336
	TARG/BAL	147/ -30	109/ 9	50/ 7	54/-11	10/ -4	4/ 1	2/ 0	392/ -36
GENERAL DUTIES	EST/ACT	647/ 328	306/ 393	207/ 214	169/150	59/ 55	20/23	9/11	1217/1191
	TARG/BAL	647/-119	306/ 87	207/ 7	169/-11	59/ -4	20/ 2	9/ 2	1217/ -36
AERONAUTICAL	EST/ACT	59/ 47	105/ 90	94/ 81	45/ 47	11/ 11	2/ 2	1/ 1	317/ 279
	TARG/BAL	59/ -12	105/ -15	94/ -13	45/ 0	11/ 0	2/ 0	1/ 0	317/ -38
RADIO	EST/ACT	74/ 40	96/ 120	95/ 57	43/ 34	11/ 9	4/ 3	0/ 0	323/ 271
	TARG/BAL	66/ -34	96/ 24	87/ -38	41/ -7	11/ -2	4/-1	0/ 0	323/ -52
ARMAMENT	EST/ACT	25/ 20	25/ 29	23/ 13	10/ 6	2/ 1	1/ 1	0/ 0	86/ 69
	TARG/BAL	23/ -3	23/ 7	21/ -10	10/ -4	2/ -1	1/ 0	0/ 0	86/ -9
INSTRUMENT	EST/ACT	26/ 18	35/ 34	22/ 10	8/ 8	1/ 5	0/ 0	0/ 0	92/ 83
	TARG/BAL	23/ -8	31/ 3	20/ -12	8/ 0	1/ 0	0/ 0	0/ 0	92/ -9
ELECTRICAL	EST/ACT	18/ 10	29/ 27	7/ 9	4/ 7	1/ 0	0/ 0	0/ 0	59/ 53
	TARG/BAL	16/ -8	29/ 1	7/ 2	4/ 2	1/ -1	0/ 0	0/ 0	59/ -4
ENGINEERS	EST/ACT	202/ 143	290/ 300	241/ 177	110/102	24/ 24	7/ 6	1/ 1	877/ 755
	TARG/BAL	180/ -59	290/ 10	241/ -64	110/ -2	24/ 0	7/-1	1/ 0	877/ -122
EQUIPMENT	EST/ACT	107/ 146	180/ 152	154/ 120	60/ 50	15/ 14	2/ 2	1/ 1	527/ 501
	TARG/BAL	93/ 39	180/ -28	142/ -34	50/ 0	15/ -1	2/ 0	1/ 0	527/ -26
WORKS	EST/ACT	4/ 6	12/ 14	11/ 5	7/ 3	2/ 0	1/ 1	0/ 0	37/ 29
	TARG/BAL	4/ 2	11/ 3	10/ -5	7/ -4	2/ -2	1/ 0	0/ 0	37/ -6
EQUIPMENT	EST/ACT	111/ 152	200/ 166	165/ 133	67/ 61	17/ 14	3/ 3	1/ 1	504/ 520
	TARG/BAL	99/ 41	179/ -34	152/ -32	65/ -6	17/ -3	3/ 0	1/ 0	504/ -64
ADMINISTRATIVE	EST/ACT	82/ 115	130/ 113	90/ 83	32/ 34	3/ 3	0/ 0	0/ 0	342/ 340
	TARG/BAL	73/ 33	133/ -17	83/ -7	34/ 0	3/ 0	0/ 0	0/ 0	342/ -2
AIR TRAFFIC	EST/ACT	100/ 100	75/ 127	26/ 20	3/ 4	0/ 0	0/ 0	0/ 0	204/ 204
	TARG/BAL	170/ -65	67/ 60	24/ -4	3/ 1	0/ 0	0/ 0	0/ 0	204/ -65
AIR DEFENSE	EST/ACT	33/ 32	22/ 19	9/ 8	3/ 4	0/ 0	0/ 0	0/ 0	69/ 63
	TARG/BAL	29/ 3	20/ -1	8/ 0	3/ -1	0/ 0	0/ 0	0/ 0	69/ -1
INTELLIGENCE	EST/ACT	13/ 10	36/ 15	20/ 15	3/ 3	0/ 0	0/ 0	0/ 0	72/ 51
	TARG/BAL	12/ 0	32/ -17	18/ -3	3/ 0	0/ 0	0/ 0	0/ 0	72/ -14
EDUCATION	EST/ACT	34/ 9	67/ 71	32/ 29	11/ 11	2/ 2	0/ 0	0/ 0	129/ 122
	TARG/BAL	33/ -25	62/ 29	29/ 0	11/ 0	2/ 0	0/ 0	0/ 0	129/ -7
COMMUNICATIONS	EST/ACT	23/ 15	10/ 13	9/ 8	2/ 2	0/ 0	0/ 0	0/ 0	42/ 38
	TARG/BAL	20/ -8	9/ 3	7/ 1	2/ 0	0/ 0	0/ 0	0/ 0	42/ -8
PHOTOGRAPHIC	EST/ACT	4/ 7	5/ 5	4/ 1	1/ 1	0/ 0	0/ 0	0/ 0	14/ 14
	TARG/BAL	4/ 3	5/ 0	4/ -4	1/ 0	0/ 0	0/ 0	0/ 0	14/ -4
POLICE	EST/ACT	5/ 7	9/ 8	10/ 6	2/ 2	0/ 0	0/ 0	0/ 0	24/ 23
	TARG/BAL	3/ 2	9/ -1	10/ -4	2/ 0	0/ 0	0/ 0	0/ 0	24/ -4
LEGAL	EST/ACT	0/ 0	2/ 7	5/ 2	3/ 2	1/ 1	0/ 0	0/ 0	11/ 12
	TARG/BAL	0/ 0	2/ 7	3/ -3	3/ -1	1/ 0	0/ 0	0/ 0	11/ 1
SPECIAL DUTIES	EST/ACT	343/ 308	344/ 376	204/ 180	65/ 63	0/ 6	0/ 0	0/ 0	1063/ 935
	TARG/BAL	343/ -35	344/ 99	180/ -6	65/ -1	0/ 0	0/ 0	0/ 0	1063/ -35
DOCTOR	EST/ACT	2/ 0	20/ 20	33/ 10	11/ 5	3/ 5	1/ 1	1/ 1	83/ 50
	TARG/BAL	2/ -2	27/ 7	30/ -11	11/ -6	3/ 0	1/ 0	1/ 0	83/ -18
DENTIST	EST/ACT	1/ 0	13/ 21	13/ 11	4/ 4	1/ 1	0/ 0	0/ 0	52/ 47
	TARG/BAL	1/ -1	20/ 8	12/ -1	4/ 0	1/ 0	0/ 0	0/ 0	52/ -5
URLES	EST/ACT	63/ 35	34/ 50	11/ 10	3/ 3	1/ 1	0/ 0	0/ 0	112/ 107
	TARG/BAL	34/ -21	30/ 20	10/ 0	3/ 0	1/ 0	0/ 0	0/ 0	107/ -5
PHARMACEUTICAL	EST/ACT	0/ 6	2/ 4	4/ 2	1/ 1	0/ 0	0/ 0	0/ 0	13/ 13
	TARG/BAL	0/ 0	2/ 2	4/ -2	1/ 0	0/ 0	0/ 0	0/ 0	13/ 0
RADIOGRAPHER	EST/ACT	5/ 5	1/ 1	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	6/ 6
	TARG/BAL	3/ 0	1/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0	6/ 0
LABORATORY	EST/ACT	0/ 0	1/ 1	1/ 1	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
	TARG/BAL	0/ 0	1/ 0	1/ 0	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
ENGINEER	EST/ACT	4/ 4	2/ 3	0/ 0	1/ 0	0/ 0	0/ 0	0/ 0	7/ 7
	TARG/BAL	4/ 0	2/ 1	0/ 0	1/ -1	0/ 0	0/ 0	0/ 0	7/ 0
MEDICAL	EST/ACT	87/ 50	103/ 120	62/ 43	20/ 11	7/ 7	1/ 1	1/ 1	281/ 247
	TARG/BAL	80/ -34	92/ 28	57/ -14	20/ -9	7/ 0	1/ 0	1/ 0	281/ -11
TOTALS	EST/ACT	1230/ 987	1243/1365	879/ 747	431/395	115/100	31/32	12/10	3941/3948
	TARG/BAL	1140/-103	1165/ 220	634/ -77	424/-20	115/ -7	31/ 1	12/ 2	3941/ -53

Fig. 5.4 Establishment/Target/Actual/
Balance (ETAB) Report

during the model advancement process to facilitate allocation of recruiting reports. This output is probably the most important output from the model, since it shows in detail the structure of each Category, Branch, and the RAAF as a whole. Furthermore, the report format exactly mirrors the display in the Directorate of Personnel Officers-Air Force strength management cell and is thus familiar to all who are interested in this type of information (and indeed was produced in this format with this objective in mind). The report is printed from arrays accumulated during the running of the model. Note that it shows the establishment, target, strength, and difference between target and strength (called "balance") for each rank in each Category. For convenience, these four figures are summed by Category, by rank in each Branch, across again to give Branch totals; then the totals of Branch/rank totals are again totaled to produce Royal Australian Air Force totals. This summary produces a detailed "snapshot" of the Royal Australian Air Force at the moment of the simulation step. Once experience is gained in reading the output, the report provides a very clear, concise picture of the Royal Australian Air Force Officer Structure. The information in the report immediately shows problem areas and can be used to develop new policies to correct these problems as previously described.

Reports from the Tabulate Option. Although the ETAB report provides a considerable amount of information in a very condensed format, often there is a need to extract more specific reports from the model. The method used by the ROS model is to allow the operator to examine the data base in a combination of ways to produce the desired results. The procedure is not unlike the CROSSTABS routines in the Statistical Package for the Social Sciences (SPSS) (1975). The "Tabulate" option always lists the selections by rank in the horizontal direction, while the following lists may be made in the vertical direction:

1. Time in Rank,
2. Length of Service,
3. Category,
4. Branch,
5. Significant Change Indicator, and
6. Eligibility for Promotion.

Once this basic selection has been made, the operator can elect to restrict to a subset of the data base, again on the basis of factors 1. to 6.. This subset can be further defined by a range of values. This is a little confusing at first sight; Categories for example are numbered from 1 to 25 and Branches from 1 to 5, in the order they appear on the ETAB report (e.g., "ADMINISTRATIVE" is Category 10, "EQUIPMENT" is Branch 3). Once the restriction is nominated, the operator can elect to define the

class width; e.g., in a years of service tabulation the operator could choose the vertical direction printout in five-year blocks. The typical use of this feature of the ROS model is perhaps demonstrated by an example. Suppose the research question was "what is the distribution of years of service for the DOCTOR and DENTIST categories?" After selecting the Tabulate option from the main program, the "2" option would be nominated to select years of service, "Y" to the question "is the tabulation to be confined in any way?", "3" to indicate the desired subset, Category in this case, "19 20" to indicate the range of the subset, and finally, "2" to indicate that the distribution was to be given in two-year blocks. The dialogue and the resulting printout for this example are shown in Figure 5.5. Although this procedure is complex to describe, it is very simple to execute, and experience has shown that once an operator has witnessed the procedure, competence follows very quickly. The power of this module of the program is that it uses combinatorial techniques to generate the reports; consequently, a large number of complex research questions can be provided with data, without the need to write special-purpose report generating programs. Use of this module is demonstrated in Chapter 7 (Validation) and Chapter 8 (Examples of Research Use).

TABULATE ON WHICH VARIABLE NUMBER? - ENTER 0 TO HAVE OPTIONS DISPLAYED
(ENTER THE NUMBER -1 TO LEAVE THE "TABULATE" MODE)

?

0

- 1 : TIME IN RANK (YEARS)
 - 2 : LENGTH OF SERVICE(YEARS)
 - 3 : CATEGORY
 - 4 : BRANCH
 - 5 : SIGNIFICANT CHANGE INDICATOR
 - 6 : ELIGIBILITY FOR PROMOTION
- PLEASE ENTER YOUR CHOICE

?

2

IS THE TABULATION TO BE CONFINED IN ANY WAY (Y/N)?

?

Y

ENTER VARIABLE NUMBER BY WHICH SUBSET IS CHOSEN

?

3

NOW ENTER PAIR OF VALUES TO BE LOWER AND UPPER LIMITS.
TABULATION IS CONFINED TO THOSE OFFICERS HAVING A VALUE OF
CATEGORY FALLING BETWEEN THESE LIMITS.

?

19 20

PLEASE ENTER CLASS WIDTH

?

2

TABLE OF NUMBERS OF OFFICERS BY RANK
TABULATED BY LENGTH OF SERVICE(YEARS)
FOR THE YEAR 1982
WITH VALUES OF CATEGORY
BEING RESTRICTED TO THE FOLLOWING:
DOCTOR
DENTIST

CLASS LIMITS	RANKS						AVM	TOTAL
	FLGOFF	FLTLT	SQNLDR	WGCDR	GPCAPT	AIRCDR		
0 - 1	0	2	0	0	0	0	0	2
2 - 3	0	25	2	0	1	0	0	28
4 - 5	0	16	2	0	0	0	0	18
6 - 7	0	9	8	0	0	0	0	17
8 - 9	0	8	7	0	0	0	0	15
10 - 11	0	0	8	1	0	0	0	9
12 - 13	0	0	0	0	1	0	0	1
14 - 15	0	0	0	3	1	0	0	4
16 - 17	0	1	1	0	1	0	0	3
18 - 19	0	0	1	0	0	0	0	1
20 - 21	0	0	0	1	0	0	0	1
22 - 23	0	0	0	0	0	1	0	1
24 - 25	0	0	0	0	1	0	0	1
26 - 27	0	0	1	2	0	0	1	4
28 - 29	0	0	0	0	0	0	0	0
30 - 31	0	0	0	0	1	0	0	1
TOTALS	0	61	30	7	6	1	1	106

Fig. 5.5 Demonstration of the Use of the
Tabulate Function

Costing. The costing report has been added to the ROS model as part of this thesis effort; it has been included as there is a growing awareness in the Royal Australian Air Force of personnel costs. A second advantage is that reducing the various inputs to the model reduces the "incommensurable" problem to some degree, in that the effects can be measured in terms of dollars and compared with other budgetary amounts. Such a facility allows reasoned tradeoffs between manpower and equipment to be made. The cost report provides two basic pieces of information--the cost of each officer who is recruited and the salary costs. To conform with other reports, the output is dissected horizontally by rank and vertically by Category, with subtotals for each Branch and for the Royal Australian Air Force as a whole. An example of this report is contained in Figure 5.6. To avoid large amounts of data entry, the cost data is contained on a data file as described above. Initially, training cost data for each Category is read into variables. This cost represents the total cost of recruiting and training a new officer and may contain elements of other costs in the Royal Australian Air Force. An example is flying training. This activity is undertaken to replace pilots lost through wastage and required by growth. The costs of running the training base, the operations, maintenance, supply and support personnel, depreciation and replacement of aircraft, fuel

RAAF OFFICER CORPS COST TABLE FOR THE YEAR 1982

CATEGORY COSTS:

	FLCOFF	FLTLT	SQMLDR	WCCDR	GPCAPT	AIRCDR	AVMM	SUBTOTAL	TRAINING	TOTAL
PILOT	5081690	8610900	5239610	4559460	1947120	810000	520000	26768780	6860000	33628780
NAVIGATOR	2494405	3894930	2462580	1886110	567910	225000	104000	11634935	2125000	13759935
AERONAUTICAL	1028500	2391800	2658200	1715000	539000	135000	52000	8517500	850000	9367500
RADIO	1006000	3024350	1827300	1431600	423500	135000	0	7847750	1000000	8847750
ARMAMENT	403800	759550	395000	237100	38500	45000	0	1878950	270000	2148950
INSTRUMENT	365800	874100	609700	274400	192500	0	0	2316500	80000	2396500
ELECTRICAL	204000	677900	305300	274400	0	0	0	1461600	0	1461600
EQUIPMENT	3005300	4011800	4238000	2247800	693000	135000	52000	14382900	294000	14676900
WORKS	119600	345050	183000	102900	0	45000	0	795550	100000	895550
ADMINISTRATIVE	2352400	3094600	2594600	1302400	192500	0	0	9536500	120000	9656500
AIR TRAFFIC	2217300	3468800	977500	137200	0	0	0	6800800	225000	7025800
AIR DEFENCE	673200	503800	303500	170500	0	0	0	1651000	0	1651000
INTELLIGENCE	361600	459300	518200	101900	0	0	0	1441000	56000	1497000
EDUCATION	204000	1858200	919500	443900	77000	0	0	3502600	0	3502600
GROUND DEFENCE	323600	367450	244600	67600	0	0	0	1003250	72000	1075250
PHOTOGRAPHIC	140700	129000	29000	33300	0	0	0	332000	21000	353000
POLICE	140000	227100	184800	68600	0	0	0	620500	26000	646500
LEGAL	0	200450	61600	68600	38500	0	0	369150	0	369150
DOCTOR	0	1036400	649700	153200	217500	51000	58000	2165800	420000	2585800
DENTIST	0	898350	390600	191500	43500	0	0	1523950	288000	1811950
NURSE	958800	1638450	307100	102900	38500	0	0	3045750	0	3045750
PHARMACEUTICAL	141400	123050	61600	34300	0	0	0	360350	54000	414350
RADIOGRAPHER	140700	26650	0	0	0	0	0	167350	66000	233350
LABORATORY	121000	25800	29900	0	0	0	0	176700	16000	192700
HYGIENE	101300	74000	0	0	0	0	0	175300	7000	182300

BRANCH COSTS:

	FLCOFF	FLTLT	SQMLDR	WCCDR	GPCAPT	AIRCDR	AVMM	SUBTOTAL	TRAINING	TOTAL
GENERAL DUTIES	7576095	12505830	7702190	6445570	2515030	1035000	624000	38403715	8985000	47388715
ENGINEER	3008100	7727700	5793500	3932500	1193500	315000	52000	22022300	2200000	24222300
EQUIPMENT	3124900	4356850	4421000	2350700	693000	180000	52000	15178450	394000	15572450
SPECIAL DUTIES	6412800	10308700	5833300	2394000	308000	0	0	25256800	520000	25776800
MEDICAL	1463200	3822700	1438900	481900	299500	51000	58000	7615200	851000	8466200

RAAF COSTS:

	FLCOFF	TLT	SQMLDR	WCCDR	GPCAPT	AIRCDR	AVMM	SUBTOTAL	TRAINING	TOTAL
RAAF TOTAL	21585095	36000000	21000000	15004670	5009030	1581000	786000	108476665	12950000	121426665

Fig. 5.6 An Example of the Cost Report

costs, etc. should be divided amongst the students trained in order to generate an accurate cost. As a consequence, these estimates may have to be iteratively developed as model output shows the number trained. Training costs are generated by interrogating the manpower data base, finding all officers with a significant change indicator that shows they have just been recruited, then costs for the Category are determined by multiplying the training cost for the Category by the number of recruits that enter. Three salary tables are used. Pilots and navigators receive flying pay and the salaries for these categories are contained in one table. Similarly, to attract and retain doctors and dentists, their pay rates are higher and are contained in a second table. Other officers are covered with a third table. Different salaries are paid for different ranks, and within a rank there are up to six pay levels; increments are given for seniority. Thus, the salary table is a 25 x 6 x 3 array. The array IOCORE is scanned and the Branch, Category, rank and time in rank are determined for each officer. This information is used to determine the correct table, rank, and seniority in the salary table; once the salary is known, it is added to the appropriate Category/rank cell in the report, as well as the Branch and Royal Australian Air Force cells. At the conclusion of these processes, the salary costs are totaled, training costs are added, and grand totals

produced. Finally, the table is printed as shown in Figure 5.6.

Comparison of the ROS Model with Personnel Division Procedures

In Chapter 1, the model was described as being "isomorphic" or having a one-to-one relationship with the real system it is designed to represent. The processes involved with personnel strength management include organizational growth, allocation of resources, wastage, promotion, and recruitment. If Chapter 2 and Chapter 5 are read in parallel, the justification of the use of the description "isomorphic" will become apparent; the model processes individual officers, described by a set of variables in a data base, in the same way as processing is done in the "real world."

A further comment on the "systems" approach may be appropriate, now that the procedures have been fully described. The intent of the strength management processes is to make the structure of the force comply with the structure dictated by the strategic assessment. Figure 5.7 shows a control diagram depicting these processes. Note that the process of achieving control over the force structure is the same for both the manual processing and the simulation model.

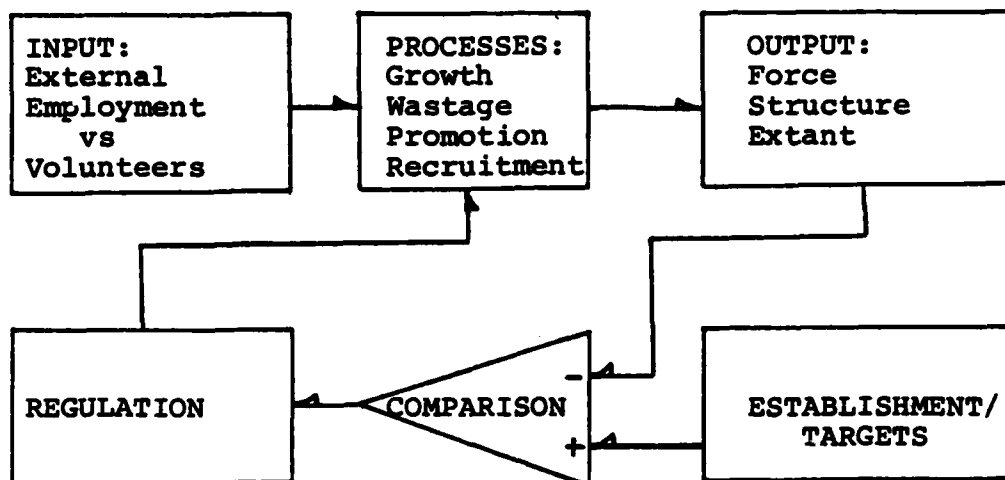


Fig. 5.7 A Control Diagram of the Major Factors in Manpower Strength Management

Summary

The way the ROS models the progress of individuals through the Royal Australian Air Force Officer Corps has been described in detail. In essence, the strategic assessment leads to the creation of the Establishment, a list of officer positions, which will change year by year. Manpower resources allocated to the Corps are distributed according to a set of deterministic rules. Officers will leave the Service, creating wastage. Both organizational growth and wastage will be accommodated by promotions and, at the lowest rank, by recruitment. Officers will grow older and will accumulate seniority in rank.

The model provides the operator with a number of outputs, including an Establishment/Target/Actual/Balance report identical to the one used presently in Personnel Division. Research on the Corps can be supported by the Tabulate function of the model which produces a variety of special-purpose reports. Cost reports are also provided.

Chapter 6

ASSUMPTIONS, APPROXIMATIONS AND FUTURE DEVELOPMENT

Introduction

If the Royal Australian Air Force (RAAF) Officer Structure (ROS) model is to be successfully used to assist strength management and research on the Royal Australian Air Force Officer Corps, the manpower resource managers must know both the way the model functions as well as the model limitations. These limitations can generally be sufficiently well understood by examining the assumptions and approximations. This chapter is devoted to a detailed discussion of the assumptions and approximations contained in the ROS model. The background to the assumptions and approximations is discussed, as is the effect on operation of the ROS model.

As an extension to the detailed description of the assumptions and approximations, information on possible development is included here as, once the functioning of the model is understood, the assumptions and approximations known, the areas in which the model could be developed closely and logically follows. A caveat on development may be appropriate at this point. Some extensions of the model will add to the complexity of the simulation.

Consequently, further development may demand more of the analyst/operator, as there is an "entry level" of understanding required if the model is to provide useful advice. Before embarking on further development (as opposed to refinement of the data that feeds the present model), the analyst should ensure that the benefits expected from the development exceed the cost.

The following paragraphs follow much the same sequence as Chapters 2 and 5; the discussion sequence will be:

1. Time Representation,
2. The Establishment Process,
3. Resource Allocation,
4. Wastage Representation,
5. Promotion,
6. Recruitment, and
7. Costing.

Time Representation

A time step of one year was chosen as this span avoids seasonal effects and ties in with the other management processes, particularly the Australian Five-Year Defence Plan, in which projects are defined and estimates are provided on an annual basis, for a period extending five years from the end of the current financial year. The ROS model is designed to provide a "snapshot" of the

Officer Corps on a particular date; generally, the most useful date will be the first of January, since the bulk of promotions takes effect on that day. Alternatively, the model can be run with a snapshot date of the first of July, since that date is the start of the Australian financial (as opposed to the calendar) year. The present intention is to use both methods by moving from the calendar year representation to the financial representation and back to the calendar year representation; i.e., making revised predictions each six months. This method of "rolling" the model forward is intended to provide up-to-date forecasts without placing an undue processing load on the strength management staff.

Although the model provides a representation at a single point in time, personnel processes are, of course, continuous. Thus, the model functions by achieving all the processes that affect each individual throughout the year, then storing the changes either in the revised manpower data base, or in tables of results, ready to be printed at the operator's request.

No changes to this way of processing are suggested; the method is standard for discrete simulation. However, it is the discrete property of the simulation that imposes the need for approximations and assumptions in other areas.

The Establishment Process

The primary assumption made in the Establishment process is that future Establishment changes will be known. While this may seem to be a trivial point, actually determining the changes is a complex business, since it depends on a great number of external (to the Director of Organization and Establishment-Air Force) factors. Furthermore, there is an inherently high probability of change in the estimates. For example, as this study was being conducted, Government policy on defense spending underwent a substantial change as attempts were made to reduce Government spending in order to reduce the budget deficit and introduce two new "unplanned" weapons systems--the aircraft carrier HMS Invincible (which will become HMAS Australia) and the replacement of Royal Australian Air Force Lockheed P3B maritime patrol aircraft with the P3C version. These changes came as a result of financially favorable offers of purchase that arose outside of the previously defined Five-Year Defence Plan. Ultimately, the likely effect of this change will be to reduce the resource allocation to other Department of Defence projects, which is likely to result in substantial changes to the previously estimated variations to the Establishment.

Many officers find it difficult to work in an environment where change is the rule rather than the exception. However, a volatile environment is the

raison d'etre for the modeling approach of management; the models allow the organization to react to the new environment with minimum effort. The most effective "mind set" is the "expected value" approach, where all the known parameters are introduced into the model and the expected result computed. Should the environment change, the new parameters are provided, new estimates produced, communicated, and revised as necessary.

A second assumption is that the rate of change of the Establishment will be known. In Chapter 4, the functioning of the RAAF Force Variation Model (FORVAR) was briefly described. This model assists the estimation of the effects of structural changes in the Service as the result of revised strategic assessments. Output from this model is not time-phased; a step change is produced. Judgement by Directorate of Organization and Establishment-Air Force personnel on both the rate of change, and the ranks affected, is required. Again, these changes depend on the timing and size of projects. As mentioned previously, these estimates may have to be revised in the light of ROS model output if the prediction is that the desired structure cannot be achieved.

A comment on the Establishment practice for the Flying Officer/Flight Lieutenant rank is necessary. Observant readers may have noticed in the ROS model output a chronic undermanning at the Flying Officer rank and a

chronic overmanning at the Flight Lieutenant rank. This imbalance is due to the time promotion as opposed to competitive promotion between these ranks. If promotion and wastage rates are high, officers will pass quickly through the more senior ranks, creating a high demand for recruits and thus increasing the strength of the Flying Officer rank. Under the present rates, officers spend more time in the Flight Lieutenant rank; consequently, this rank is overmanned in comparison to the Flying Officer rank. The model in its present form accurately represents the real situation, hence changes should not be made to either the establishment levels or the promotion algorithm, unless a change is first made in the Service.

Generally, the model representation of the Establishment process is satisfactory; no useful areas of development are seen.

Resource Allocation

Comments similar to those made on the Establishment process can be made on the variability of the strength allocation to the Officer Corps. However, in the case of strength allocation where a single figure is provided as input to the model, reaction to a change is relatively simple.

Within the Officer Corps, the allocation of the manpower resource to Categories and ranks is based on

arbitrary rules. The implicit assumption is that these rules provide the best allocation of manpower, when allocated strength falls short of the Establishment. A change in either the strength allocation or the total Establishment could induce a change in the rules. For example, if Establishment grows while allocation strength declines, the present rules will result in very (perhaps unacceptably) low manning levels at the junior ranks. The converse is also true. However, if either of these situations arise in the future, these problems will become evident in the manual system. The ROS model may, though, give an early indication of unacceptable imbalances between the ranks, in which case the prediction produced by the model could be used to make changes in the strength allocation rules.

Finally, there is interaction between officer wastage rates and the strength allocations made to the Officer Corps. When wastage increases, larger numbers of recruits are required. In the Royal Australian Air Force, a substantial portion of these recruits is provided by the Officer Cadet Corps, which has its own strength allocation extracted from the Royal Australian Air Force's allocation to both the Officer and Cadet Corps. An increase in the Cadet Corps is accomplished at the expense of the strength of the Officer Corps. Since the Cadet Corps provides future officers, it has first call on the

strength allocation. Thus, as wastage rates rise, there is a second order interaction with the Officer Corps strength allocation. Such an effect is expected in about five years when the "Vietnam Hump" reaches the twenty years of service/eligibility for a pension/high resignation rate zone. Analysts should be aware of this interaction and be prepared to iteratively develop new strength allocations.

This effect could be modeled by treating the Authorized Terminal Strength passed to the model at the combined Officer and Cadet Corps allocation and using a decision rule to divide the allocation between the two Corps. This comment outlines a possible development of the ROS model.

Wastage

The structure of the Royal Australian Air Force is most affected by wastage of officers. Each year, between 200 and 300 officers leave the Service, while growth in recent years has been only about 50. Only in recent years has the sensitivity of the structure to wastage been recognized, and readily accessible and detailed data bases on losses of officers only extend back to 1 January 1975. Thus, there are only about 1500 cases from which to draw inferences.

One of the problems with making predictions from a small data base is the problem of small sample size. If similar work were being done in, say, the United States Air Force, an annual loss rate of 6 percent per annum would produce 7800 losses from a force size of 130,000 officers. This large wastage data base would allow reasonably accurate statistical evaluation to be made. In the case of the Royal Australian Air Force the estimation methods are limited by the amount of data available.

Ideally, wastage estimations would be made using all the variables that describe each officer; i.e., years of service, Category, rank, and time in rank. Just using the first three, years of service (forty years maximum), Category (twenty-five), and rank (seven) gives 7000 possible data points. The actual modeling method is to use years of service (forty) and Branch (five) to give 200 data points. The assumption made is that the most important factor in determining wastage is years of service, with modifications to the wastage patterns being imposed by the Branch. The method of determining the expected value of wastage is to divide the strength of the Officer Corps into the 200 cells of years of service and Branch, then determine the losses from each cell. These loss rates then become the expected values for wastage used in the model. A second problem arises at this point. If reasonably large losses per cell are to be obtained to

reduce variability, a large number of observations must be obtained. The problem is that if large numbers are obtained by using several years of data, the wastage patterns may be out of date by several years.

The requirement to limit the representation of wastage patterns by Branch is reasonable in those cases where the Branch is homogeneous (e.g., the General Duties and the Engineering Branch), but may lead to inaccuracies in other Branches, such as the Special Duties and the Medical Branch. For example, can Administrative Officers be expected to have the same wastage patterns and rate as, say, Air Traffic Control Officers? Another example is the wastage behavior of Doctors and Nurses.

Another wastage factor is the effect of internal and external forces on each officer to leave the Service. This problem is perhaps best described by an example. Several years ago, there was a world-wide surplus of engineers. As a result, fewer people entered engineering courses. Meanwhile, the situation throughout the world changed and there is now a world-wide shortage of engineers. This cycle has taken place in less than ten years. A counter cycle seems to be occurring for doctors, at least in Australia. These changes in external employment opportunities can reduce the predictive power of the simulation. Internal changes can change wastage rates. For example, the United States Air Force is about to offer bonuses to

Engineering Officers (no doubt as a result of the shortage mentioned above); if this measure is as effective as is hoped, wastage amongst the eligible cohort will decrease, while recruitment will improve. Such a situation will introduce a discontinuity both into the structure of the Service, and the wastage rates for these officers. Predicting these discontinuities is practically impossible.

A further example is the effect of gender on wastage patterns. In recent years, the Royal Australian Air Force has been accepting greater numbers of women officers and this trend can be expected to continue. Women officers have a substantially different wastage pattern from men; they tend to leave the Service much sooner. At present, there are less than 250 women officers in the Royal Australian Air Force, and the effect of the different wastage patterns is in practice insignificant. However, if the increased recruiting of women continues, some allowance will have to be made for this factor, or the model will produce distorted results. The only change needed is to accurately represent the wastage pattern of women officers. While this may require the expansion of the data base variables to include gender, the present method of processing will make the required predictions.

One aspect of wastage that has not been included at all is "age" retirement. The Royal Australian Air Force

does have mandatory retirement for all officers when they reach a certain age. This age depends on the officer's rank and Branch. The reason for not including this factor into the wastage algorithm is that age retirement accounts for a very small proportion of total losses (about 15 percent), and this figure is diminishing each year; with current wastage rates, the average years of service for the Officer Corps is decreasing. Furthermore, there is a high correspondence between years of service and age, and the wastage patterns presently used tend to capture age retirement. Finally, adding age retirement to the wastage model would require an additional variable in the data base--the date of birth of each officer. Modeling age retirement explicitly could be a useful addition to the model, particularly if the average age of officers on their departure from the Service rises, as could happen if wastage rates drop significantly.

This discussion highlights the assumptions and approximations made on wastage by the model. They are:

1. Wastage may be adequately represented by a wastage model based on years of service and Branch;
2. The past two years of wastage data provide a reasonable representation of future wastage patterns;

3. Wastage patterns in a Branch are representative of the wastage patterns for each Category within the Branch;
4. Changes in internal and external (to the Royal Australian Air Force) conditions can be represented by shifting the whole wastage table by some factor;
5. There is no difference between the wastage patterns for men or women officers; and
6. No explicit treatment of age retirement is included in the ROS model.

The foregoing suggests that considerable work could be done on the section of the model that predicts wastage. Such work will be difficult, and the problems go beyond the problem of small sample sizes. A common method of creating such models is to use multiple regression techniques. These models cannot be used here as the factors generating wastage are not continuous. An example is eligibility for a pension. Prior to twenty years of service, an officer is ineligible for a pension. After becoming eligible, the wastage rate increases by about an order of magnitude. To see this effect, examine the SYSDATA wastage table or, alternatively, examine Figure 6.1 which shows a plot of the wastage rates for General Duties officers, one of the five wastage tables included in the SYSDATA file. Although regression models show some

RAAF GENERAL DUTIES BRANCH:

Wastage Rate versus Years of Service.

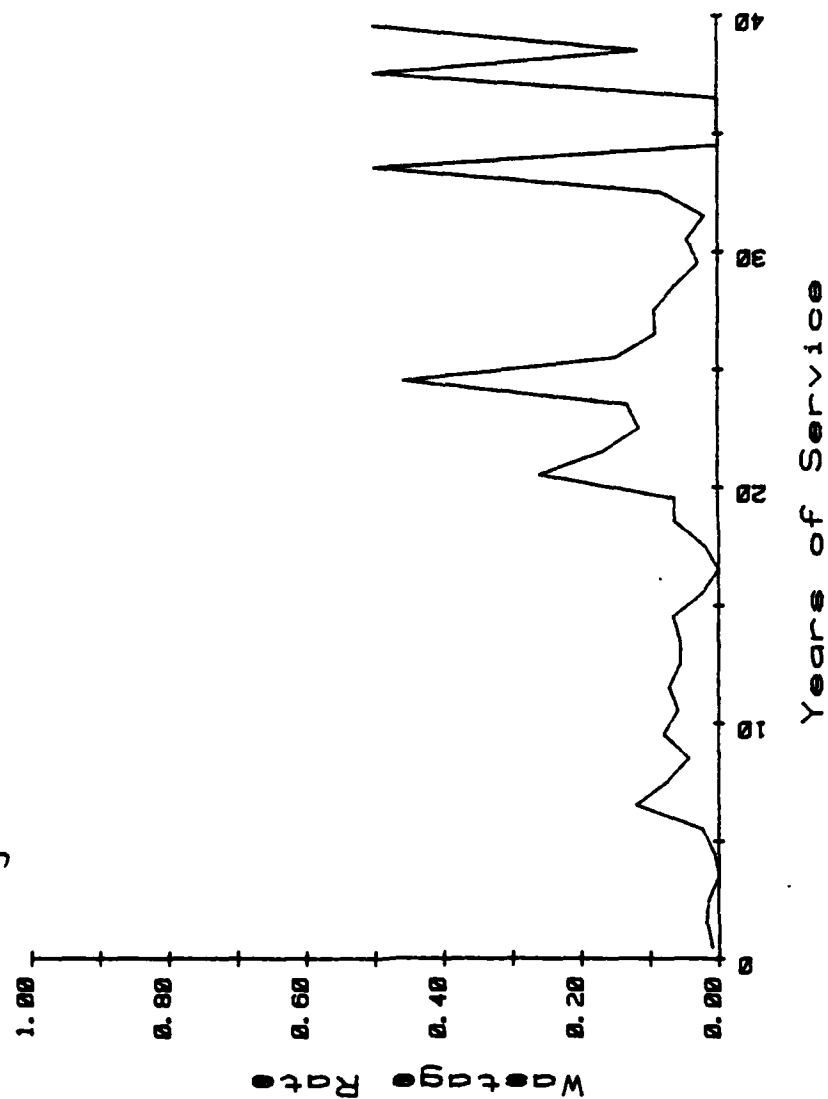


Fig. 6.1 Wastage Rate versus Years of Service

correlation of wastage rates with years of service (e.g., the General Duties Branch rates exhibit a correlation coefficient of 0.51), the accuracy of the linear prediction is reduced by the discontinuity of the underlying process generating the wastage. The approach taken here is to determine wastage using a probability approach: years of service and Branch data are used to determine the cell from which the probability of wastage is drawn; in turn, this probability is compared with a computer-generated random number to determine whether the individual leaves the Service. This method is seen as preferable to determining wastage from a function.

Although such examinations of wastage are highly desirable, the study could be expected to be very difficult. One suggestion to improve the consistency of the predictions is to use the same approach as in the present model but to classify Category wastage patterns by their similarity, rather than by Branch. Statistical techniques such as the Pearson Correlation/Chi-square test (Mendenhall, Scheaffer, and Wackerly, 1981:549) could be used to classify wastage patterns. This approach could address the problem of different patterns between men and women officers. Other facets of such an investigation could be the determination of the optimum number of wastage patterns to retain in the model, and the effects of age retirement on wastage.

Promotion

The area of the ROS model that departs most from the ideal of isomorphism is the promotion algorithm. The problem is that competitive promotions are (theoretically) based on the quality of the eligible officers. Coping directly with "quality" issues in a quantitative model is very difficult; in fact, making a model that has the necessary one-to-one relationship with the real world is impossible for the following reason. An accurate promotion model can be made using a regression model containing performance assessments and seniority; such a model was constructed in Personnel Division and was predicting well over 90 percent of promotions (Mills, 1979-81). While this would allow the model to advance one year, the difficulty then becomes generating the performance assessments for each individual in the subsequent years.

Cognizance of this problem led to the use of the present promotion algorithm. The promotion model uses time in rank as the prime predictor of promotion. This is a reasonable practice, as promotion boards have recently been using a weighting factor of up to one standard deviation per year to bias promotions to favor the officers with seniority. Although this practice is not written down as policy, it can be easily demonstrated with regression analysis. (This work was done by the author during his tour in the Directorate of Personnel Officers-Air Force,

in order to help formulate the promotion algorithm used by the ROS model.) Furthermore, given the high correlation of promotion selection with time in rank, using this selection method is likely to provide good predictions of the behavior of the promotion system, even if individual officers are not modeled exactly. To model the fact that job performance is also a factor, a random selection of officers is made, starting with the most senior in rank. The model will fail to promote if the random number drawn for the officer is larger than a parameter for that Category/rank cell. The process continues until all eligible officers have been examined. In most cases, the available vacancies will be filled before reaching the most junior officers in the rank who are eligible, thereby generally promoting the most senior before the most junior, yet selecting a mix of officers.

The eligibility issue bears discussion. The minimum time in rank to become eligible is shown with certainty, as this is determined as policy by Personnel Division and is fairly stable. Generally, an officer must have four years time in rank to be considered for promotion. However, this minimum time in rank can be different, usually as the result of substantial deficiencies or surpluses of officers eligible for promotion. For example, Flight Lieutenant Doctors may (in this version of the model) be promoted with only two years time in rank, while

Flight Lieutenant Air Traffic Controllers require a minimum of six. The minimum time in rank to become eligible is likely to change when the supply of officers eligible for promotion changes, although in the present implementation of the model, this figure is assumed to be constant for the duration of the simulation. The concept of maximum time in rank for eligibility is used in the model but has no parallel in the promotion practices. However, some officers have such low performance assessments, that they are effectively "unpromotable" or, alternatively, they may advise the Director of Personnel Officers-Air Force that they do not wish to be promoted. Examination of the Air Force List, Australian Air Publication 598 (this document annually lists all Royal Australian Air Force officers; see the reference list (1981)), shows this number to be about 15 percent of eligible officers. Modeling the "unpromotable" officers is achieved by declaring a five-year promotion zone; if an officer has not been promoted after five years of being eligible for promotion, he is deemed "unpromotable." At present the promotion probability is set at 0.3. Thus, if an officer is examined each year for five years, the probability of nonpromotion is:

$$(0.7)^5 = 0.168$$

Thus, the generation of "unpromotable" officers closely follows the current behavior of the promotion system.

The analyst has three parameters to describe the promotion system--minimum time in rank to be eligible, the promotion probability, and the maximum number of opportunities for promotion. The first parameter is effectively fixed. The analyst may "juggle" the second two parameters to produce an acceptably accurate representation. For example, to reduce the bias for seniority, increase the promotion probability, while reducing the time the officer remains eligible, at the same time select parameters that produce a comparable number of "unpromotables." To demonstrate, the promotion probability could be increased to 0.45, while the eligible period decreased to three years. This would yield a probability of nonpromotion of:

$$(0.55)**3 = .166$$

Only the ranks Flight Lieutenant, Squadron Leader and Wing Commander compete for promotion. For the Flying Officer rank, promotion is automatic at minimum time in rank, although some (albeit very few) officers do not complete promotion examinations in time and have their promotions delayed for a year or so. Most of these officers are subsequently promoted. In the ranks of Group Captain and Air Commodore, where numbers are small, promotion is simply based on seniority.

The foregoing suggests that the following assumptions and approximations have been made for the promotion process:

1. The promotion process will be unchanged for the period of the simulation;
2. The promotion process can be adequately represented by the factors:
 - a. Minimum time in rank,
 - b. Fixed number of chances for promotion,
 - c. Probability of promotion in any year;
3. The most senior officers in a rank will have the first opportunity for selection;
4. Senior officers will be promoted in seniority order; and
5. Junior officers (Flying Officers) will be promoted on reaching minimum time in rank.

Some suggestions for improvements can be made.

Firstly, an examination of promotion data has not yet been made to determine the best set of parameters; the parameters used have been based on the judgement of the author, as time did not permit the necessary data analysis to be completed. This process of data refinement should be carried out as part of the implementation of the model. Secondly, the algorithm itself could be extended to include the failure of some Flying Officer to be promoted, and/or extend the competitive promotion system to the ranks of Group Captain and Air Commodore. Other than these minor improvements, which may not be necessary at the level of accuracy desired, the opinion of the author is that the

present algorithm is probably the best that can be done in this difficult (to simulate) area.

Recruitment

Recruitment is at the end of the processing chain and is sufficiently complex to deserve modeling in its own right. However, in the ROS model, the output of the recruiting system is modeled as a single input figure for each Category, with a constraint of maximum number of recruits in that Category imposed; the program selects the lesser of the demand and this constraint. A new constraint figure is provided for each year of the simulation. In addition to the constraint, recruits (more correctly called "appointees") are injected with a number of years of service. Finally, in some Categories, officers are appointed at Flight Lieutenant rather than Flying Officer rank. These parameters are discussed below.

Recruiting Constraints. The variable "MAXREC" contains this constraint. The purpose of this variable is to allow the model to represent limits on recruiting that may arise from a number of resources. The most common limitation on recruiting is simply a lack of sufficient volunteers from which to select sufficient officers of the required minimum quality to meet recruiting requirements. An example is in the Engineer Branch. Despite vigorous recruiting efforts, the demand for Engineers in

the community exceeds supply, and the Royal Australian Air Force cannot get sufficient volunteers. (The problem is at least partially solved by obtaining Royal Australian Air Force Engineers via an officer cadet scheme.) A second source of limitation is a limited training resource, which may arise from the number of instructors available, or the facilities. For example, presently the Royal Australian Air Force is having some difficulty providing officers with their initial introductory training course; only 200 to 220 positions are available annually, and these must be apportioned amongst the Categories. Determining the recruiting constraints thus takes some skill, and a substudy may be required to provide accurate figures. Although the recruiting constraint is a complex issue, it may be adequately represented by a single number for each Category for each year of the simulation.

Years of Service on Recruitment. There are several paths to appointment as an officer; the number of paths depends on the Category. For example, in the case of the Pilot Category, the path is either via the Royal Australian Air Force Academy, when the officer will have four years of service on appointment, or via the officer cadet pilot training scheme, where the officer will be appointed with a little more than one year of service. Airmen of the Royal Australian Air Force may also become officer cadets

in which case they may have several more years of service. In other categories officers may be appointed directly, in which case they will have no years of service on appointment. Again, airmen may be appointed directly with several years of service. If all recruits are "created" with zero years of service, the subsequent representation of wastage will not be accurate as the recruits will not be placed in the correct "bin" of years of service when wastage probability is being determined. A simple solution to this problem is adopted in the present implementation of the ROS model. When a recruit is generated, the figure used for years of service on appointment is that obtained from the system data parameter "YOSREC." This simple representation is not entirely satisfactory, since all recruits in a Category have one value of years of service while, in reality, they have a distribution of years of service. The effect is noticeable as a discontinuity when the Category years of service are listed via the Tabulate option. The solution to the problem would be to draw recruits from a distribution that accurately describes the years of service distribution for each Category. A possibility would be a lognormal, with values rounded to integers. Although this enhancement may appear to be desirable, it may not be necessary. Generally, the model will only be used to predict manpower states for a period of five years or so. The distortions induced by a single value for years of

service on recruitment over this time period are expected to be minor. A further approximation on years of service on appointment is that the number is necessarily an integer. Since most officers are appointed in the beginning of the year, the minimum value that is used is zero, typically in the Categories where the majority of recruits are directly appointed civilians. In other cases, the value used is the nearest integer of the average of the years of service in appointment.

Rank on Appointment. In some Categories (namely LEGAL, DOCTOR, and DENTIST), officers are appointed with one year of service, but at Flight Lieutenant rank. Since there are few exceptions to this rule this provides an accurate representation of current policy. Should lateral recruiting become a significant source of recruitment, for example as a result of recruiting officers from other Services with substantial experience, leading to appointment at ranks up to Wing Commander, some modification to the program would be required.

Summary of Assumptions and Approximations. The following is the summary of assumptions and approximations:

1. The output of the recruiting system can be adequately described by a constraint on recruits for each Category for each year the simulation will be run;

2. A single figure is used to represent the years of service of a recruit on appointment, this value is considered to be stable through the simulation; and
3. In some Categories, rank on appointment may be Flight Lieutenant rather than Flying Officer, but no higher.

Enhancements. The model could be made more accurate by using a distribution to generate years of service on appointment, although for short simulation periods (five years or less), the inaccuracies are expected to be minor. Another improvement could be an extension to the recruitment algorithm to allow appointment at several rank levels. Again, a distribution of levels would be required. This extension of the model would only be required if lateral recruiting becomes significant.

Costing

The cost report generator expresses the structure of the Service, and the recruiting undertaken, in dollars. The purpose of this report is to allow comparisons to be made with other activities in the Service, which are also expressed in cost terms.

Cost Timings. The most difficult issue in presenting costs, while using reasonably simple concepts, is the

question of timing of cost accrual. The cost report attempts to provide cost summaries for the preceding year of the simulation report date. This classification of report type is important; all other reports either give the state of the Service on a particular date (usually 1 January), or the events that have occurred in the previous twelve months (e.g., number wasted, promoted, recruited). The latter case is used for the cost report. This means, though, if the costs for the calendar year 1984 are required, the simulation must be advanced to 1 January 1985, then the costing report obtained. A second issue is the representation of training costs. In many cases (e.g., Engineer officer cadets), the appointees may have undergone several years of training by the time they are appointed. The present implementation provides a single cost figure for this training. The effect is for such recruits to bring several years of costs with them. Furthermore, this single figure assumes a constant mix of officers from the several avenues of entry to the Officer Corps. When the recruiting process is volatile, the mix may change and the costs no longer accurate.

Errors in Salary Costs. Some minor errors are inherent in the costing process. Firstly, only seven of the nine ranks (in which there are, on average, at least

one person) of the Royal Australian Air Force are represented in the ROS model. The Pilot Officer rank is merged with the Flying Officer rank as the former is effectively a probationary rank. However, salaries are lower in the Pilot Officer rank and so the model overestimates costs by excluding this rank (so long as Flying Officer rank salaries are used for all officers in the rank). The error is not severe. A check of the Air Force List (see references) shows only 150 pilot officers in the Officer Corps. The difference between Pilot Officer and Flying Officer salary (at January 1982) is \$1200 per annum, making the error an overestimation in estimation about \$180,000 per annum, or about 0.17 percent of total salary costs, which are about \$107M per annum. Moreover, this error is offset by the salaries received by officers who have been commissioned from the rank of sergeant or above who receive a higher salary until reaching the rank of Squadron Leader. The precise number of officers in this Category cannot be accurately determined with the data available; however, about fifteen such commissions per year occur. Assuming these officers serve for an additional nine years at a salary differential of 2500 (again January 1982 figures), the error in this category is $15 \times 9 \times 2500$, or \$337,500. Taking into account the overestimation of salaries of Pilot Officers, the cumulative error in the total salary costs is an underestimation of

about \$157,000 or 0.15 percent. Finally, Chaplains (who have not been mentioned before and who are not included in the model since their advancement is different from the rest of the Service) could be included. Assuming the thirty Chaplains in the Service receive an average salary of \$25,000, the salary for these officers is \$750,000, now restoring the balance to an underestimation of the total salary costs by about \$593,000 or about 0.55 percent. The importance of these costs depends on the use to which they will be put. The present manual system of estimation allows an error of 0.3 percent, thus the present method of estimation is marginally acceptable. With some additional support studies to balance the salary figures, rather than using the salaries directly from the salary scales, greatly improved accuracy could ensue. A final source of inaccuracy in salary costs is the assumption made about the average strength of the Officer Corps. The present assumption is that the basis for the year's costs is the structure extant on the first of January is the structure for the whole year. Since the model steps forward in a time step of a year, the changes within the year cannot be modeled directly, and some assumption must be made about the strength change process. The decision made here is to let the final strength represent the structure for the preceding year. This assumption is the best that can be made under the circumstances; at present there is

no definitive Department of Defence policy on managing strength changes. When an increase is allowed, the Services try to maximize gains early in the calendar year as this is the most favorable time for recruiting. Furthermore, most officer resignations take place at this time. Thus the assumption used is the most reasonable one, given the limited resolution of the model in this area. Improved accuracy of costs can be obtained by using average strength, rather than the Authorized Terminal Strength. Notwithstanding the foregoing, the advantage of the modeling approach over the present method, which is a manual projection from last year's figures, is that the model will make adjustments to costs that result from the structural changes in the Service, whereas the present methods do not. Given that the data are already in the model, the ROS program will provide estimates with much less work.

Errors in Training Costs. The stability and accuracy of costs is much less satisfactory in the case of the estimation of training costs. One difficulty in the model is that the cost of all recruits is considered to be incurred in the year of recruitment, while the costs may actually be sustained over several years. Simplicity of the model is the reason for this cost treatment. This assumption will not give large errors in a stable Service; however, when the wastage rate is changing, the costs will

lag actuality. The concept of costing the training used to replace wastage and accommodate growth is a new one, and great difficulty has been experienced obtaining representative costs. No directives within the Australian Department of Defence that detail the costing of training (i.e., what costs are to be included) are extant. This facility of the model should be thought of as "experimental," waiting in the wings until a need is expressed. The concept of a single cost for each Category may be too simplistic. Given the "newness" of this work, the decision was made to make estimates of the Category costs per recruit and include the facility more as a demonstration of what can be done, rather than suggesting the method is the final word in accuracy. Hopefully, this aspect of the model will be developed in the near future. Training costs are, of course, very sensitive to wastage rates. If an accurate training cost model can be developed, tradeoffs between additional salary/conditions of Service versus wastage (and hence training costs) will be able to be made. Such information could add considerable credibility to arguments presently made in these areas.

Inflation and Net Present Value. In its present form, the model makes no allowance for inflation. All costs are expressed in "now year" dollars, where the salary scales and estimated training costs in the base year are

used as the basis for the whole simulation. Estimating future inflation is fraught with difficulty. Furthermore, Governments traditionally tend to represent future inflation as the figure they would like rather than expect; this approach can lead to gross underbudgeting. Similarly, estimation of net present value has not been made, as the discount rate is subject to debate and, in any event, the concept of net present value is not widely used in the Australian Department of Defence, at least not as widely as in the United States Department of Defense. Furthermore, training and salary costs cannot be either paid in advance or deferred, effectively negating the concept of accruing future costs to present value. A final consideration is the use that is to be made of the cost information. If the cost data output from the model is used to estimate the relative (cost) effect of changes, the advantage of constant dollars is that direct comparisons can be made from one year to the next. Given these limitations and considerations, the decision was made to simply use constant dollars throughout. The model can be readily modified to include inflation or net present value calculations, should this be necessary.

Assumptions and Approximations Made in the Costing Report. The assumptions and approximations made in the costing report are:

1. **Salary Scales.** Three salary scales are considered sufficient to represent the salary costs of the Royal Australian Air Force, although some errors are inherent in this approach.
2. **Structure used for Costing Salaries.** The model uses the structure extant at the end of the year as a basis for salaries paid in the previous year.
3. **Training Costs.** A single figure is used to represent the cost of recruiting and training each officer who enters each Category.
4. **Inflation and Net Present Value.** No allowance is made for inflation or discounting in the cost report.

Development. The representation of costs is an entirely new development of the model, in a new area to the Service, namely converting the representation of the Officer Corps into a cost table containing both salary and training costs. At present, the uses for this information are largely unknown. Accordingly, the present representation should be considered to be a first iteration. After the information is presented and potential users appear, the second iteration can start. The other modules in the ROS program have undergone several cycles of

development in such a process. As a guide, the costing module should be examined to see whether adjustments to the data, or recoding are required to provide the necessary information. In many cases, intelligent use of data which is analytically designed to represent the expected case, can produce the desired result, rather than producing complex code that must be frequently amended to follow changes in policy and practices within the Royal Australian Air Force.

Summary

Since the ROS simulation is discrete and steps forward one year at a time, while the actual process is virtually continuous, a number of assumptions and approximations have to be made. An understanding of these allows the analyst to make the most effective use of the model. Furthermore, areas of development follow immediately from the approximations.

The ROS model, like any "working" simulation, should not be considered to be fixed; most modules have already been through several iterations. As the model is used, and as the Service finds the environment changes, more development will be required to maintain the accuracy and usefulness of the model. The descriptions of the assumptions, approximations, and suggestions for development are designed to assist this iterative development.

In the next chapter, the issues of verification, variance of results, and model validation are discussed. In many ways, these three topics are closely linked to the assumptions and approximations made in the model. Accordingly, Chapters 6 and 7 should be considered as a pair.

Chapter 7

VERIFICATION, VARIABILITY AND VALIDATION

Introduction

The subject of interest in this chapter is the issue of validity. Two terms are of prime interest; verification and validation. Definitions of these terms have been provided by Fishman and Kiviat (Law and Kelton, 1982:333-334) and are:

1. "Verification is determining whether a simulation model performs as intended."
2. "Validation is determining whether a simulation model is an accurate representation of the real-world system under study."

The concepts of the chapter are based on discussions on the subject recorded by Arnett (1979), Law and Kelton (1982), Naylor and Finger (1967), and Shannon (1979). The intent of the chapter is to avoid as far as possible, the philosophical issues in the validation problem, and concentrate on describing a simple, straightforward strategy that can be used by analysts to validate the model as changes are made. The reason for this approach is that the Royal Australian Air Force (RAAF) Officer Structure (ROS) model must be a dynamic entity, changing as

procedures in the Royal Australian Air Force Personnel Division change, if it is to retain its usefulness. A limitation of the present study is that circumstances preclude the completion of a full validation cycle; the necessary data cannot be obtained from the sources in Australia in time to complete the process.

Approach. The sources quoted show some degree of consensus on the issue of validation. Shannon (1979:215-217) includes a "utilitarian" approach and, since the model is designed for pragmatic purposes, this is the procedure that will be followed. The procedure he suggests is:

1. Constructing a set of hypotheses about the manner in which the sub-elements interact based on all available information including: observations, previous research, relevant theory, and intuition.
2. Attempting to verify the assumptions of the model whenever possible by statistical testing.
3. Comparing the input-output transformations of the model whenever possible with those of the real world.

The first step is the "face validity" issue which has been closely documented by the foregoing chapters of this study, thus further comment on this aspect would be redundant. The rest of this chapter concentrates on the issues of verification and validation. A section of the chapter discusses the variability inherent in the model to assist an understanding of the validity tests.

Philosophical Base for the ROS Model. Before proceeding, two "philosophical" points will be made. The first point is that the prime assumption of the model is that if the model is provided with accurate data, and the processes within the model are close approximations to the real world, then the outputs from the model will closely approximate the events in the real world. This is the "expectation" approach; if the model and data are accurate, we expect the predictions made by the model to be the "best estimate" of what will happen in the real world. Following from this idea is the concept of updating the model. As new data are available (or new processes adopted), the model will cease to provide the "expected" outcome until the necessary modifications are made. The second point is that validation is measured by degree, rather than by the dichotomous measure of being either "valid" or "invalid." The model is "valid" when it predicts the outcomes in the real world with sufficient accuracy. Shannon (1979:208-209) discusses the tradeoff between cost and benefit of a model. The analyst should always be aware of these two factors and cease to seek improvements when the model is providing sufficient accuracy.

Verification

Verification is relatively easy in this model, since there are a large number of outputs that show the

details of the state of the model. Examination of these reports usually shows the internal functioning directly. Considerable work has been done on verification during the development of the model. The user of the RAAF Officer Structure Model (Director of Personnel Officers-Air Force) and the developer (Central Studies Establishment) worked closely, and many iterations of verification were carried out during the construction of the model. The subsequent paragraphs detail the processes required for a complete verification.

The analyst attempting to verify the model should have a copy of the source code, plus a copy of the establishment, system, and cost data files. At times it may be necessary to amend the code to provide specific diagnostic outputs. (Note that this "debugging" code was removed after the program was initially verified. Should changes be made to the model, the revisions should be accompanied with new versions of "debugging" code.) The model output can then be compared with the input data to form the verification process. One assumption that will be made is that if the program works correctly once, it will not be necessary to repeat the checks; while this may appear to be a trivial point, it obviates the need to make verifications for each time step of the simulation.

Establishment. The Establishment is initially read in from the establishment file. To check the segment, print the Establishment/Target/Actual/Balance (ETAB) table using the "E" option. Check for conformity between the establishment file and table. Summaries across a Category, Branch, and for the Royal Australian Air Force will have to be checked by manual addition. Next, advance the model using the "G" (for "GO") option. Print the ETAB table again, and using the establishment variations in year 1 contained in the Establishment file, check to see if the correct variations have been made. Repeat the process once more to check that the program is reading the next year's variations correctly. A common error that could occur here is the deletion of a Category line; since the file is read serially, such an error will place all subsequent variations out of phase with the correct Category.

Resource Allocation. The program allocates the given Authorized Terminal Strength according to allocation rules that have been programmed, rather than rules based on a data file. Should these rules change, the program will have to be amended, and a new verification should follow. Using any year in the simulation, nominate the Authorized Terminal Strength when asked, then print out the resulting ETAB table. Using the rules for strength

allocation, check to see if the program has actually followed the rules. Be aware that the program will round the values to an integer. Finally, add the resultant allocations to ensure that the Authorized Terminal Strength stated to be used is actually used. Since the allocation process is the same from year to year, there is no necessity to repeat the process.

Wastage. Wastage is the first stochastic process in the model. In the verification of wastage, the item of interest is whether the model is correctly identifying the individual officer by Branch, subsequently selecting the correct wastage table and years of service, then correctly comparing the random number with the probability of wastage found from the wastage table. To complete these functions, the source code should be modified to provide the necessary output. Subroutine NEXTYE should be enhanced to print the individual officer's time in rank, years of service, rank, Category, Branch, significant change indicator, and eligibility for promotion. (Only years of service, Branch, and significant change indicator are required here, the other variables can be used for other verifications mentioned below.) Subroutine ANS (= answer) should be modified to print out the random number selected, the wastage probability, the factor for wastage and if wastage has occurred, the revised significant

change indicator. These printouts should be examined to see if the program is identifying the correct wastage probability to use (see the system file for the tables) and that when the random number is less than the wastage probability multiplied by the wastage factor, wastage is identified by the amendment of the significant change indicator to the value 4. The analyst should be aware that each officer in the data base will be examined, and that lengthy output (several thousand printed lines) will result. A subset of the output will usually be sufficient to verify this part of the model. An alternative source of diagnostic data is temporary file 66; as officers are wasted, they are written out onto this file. Stopping the simulation at the end of the year and dumping the file to the printer will allow the wastage in a year to be observed.

Promotions. Verification of the promotion process is somewhat more complex than verification of the wastage process, since there are three separate algorithms, depending on rank. Group Captains and Air Commodores are promoted in seniority order if there is a vacancy. Flight Lieutenants to Wing Commanders compete for promotion while all Flying Officers are promoted if they have the minimum time in rank. All the code for promotions is contained in the subroutine ANS. The verification procedure

suggested is very similar to that used for the wastage check. First print the officer's variables from the data base. Next, the eligibility for promotion is calculated from time in rank and the table minimum time in rank contained in the systems file and should be printed. For the Group Captains and Air Commodores, promotion is automatic, provided there is a vacancy. The presence of vacancies can be determined from the arrays NOBRNE (= number borne) and TARGET, calculated from the Authorized Terminal Strength as described previously. While the number borne for the rank/category is less than the target, promotion will occur. Printing the values of these arrays and the subsequent significant change indicator will confirm the promotion. A significant change value of 3 is used for promotions. Competitive promotion is very similar, with the addition of a random number of select promotees. The probability of promotion is contained in the array PROTAB, also contained in the systems file. A random number is drawn, and if less than the promotion probability, the officer is marked as being promoted. Printing these values will allow the procedure to be checked. Promotion of Flying Officers simply involves a check of achieving minimum time in rank. Again, printing the officer's variables, checking the minimum time in rank from the system file, and the significant change indicator will determine the flow of the process. An alternative to special

diagnostic code is the file 23 onto which promotees are written for later retrieval. If this file is dumped to the printer at the end of the year, the year's quota of promotees can be observed. The final process that must be checked is whether the program is promoting to vacancies. This is a more difficult problem. Vacancies for promotion to a Category/rank cell result from an initial shortage in the Category/rank cell, wastage from the cell, and promotions from the cell to the next highest rank (except for the Air Vice Marshal rank). The model keeps track of these values by amending the array NOBRNE in several segments of the program that deal with these processes, and verification using printouts is clumsy. Perhaps the easiest method is to use the tabulate option to print the significant changes for a single Category, using the "tabulate" option. This printout should be compared with the ETAB tables for the years that straddle the report. Comparison of the tables allows the analyst to determine whether the program is correctly keeping track of the vacancies.

Recruitment. Verifying the recruiting processing has many of the same problems as verifying the promotion vacancies. Recruiting is the end product of wastage and growth in the Officer Corps; note that recruiting is not affected by promotion, and that the model may increase the strength of the lowest rank beyond its target if the

wastage or growth is high in the senior ranks. The code for recruiting is found in the ANS subroutine. Each Category is processed separately, with the demand for recruiting being determined from the target and strength in each rank. If the Category is over strength, attrition is used to restore the balance, while if under strength, the recruiting requirement is totaled, and the lesser of the recruiting requirement and the recruiting limit found in the systems file is used to "create" recruits. This process can be followed by inserting the appropriate diagnostic print statements in the ANS subroutine, between labels 200 and 350. The variable NREC is used to determine the recruiting requirement, while LIM and MAXREC(Category) hold the recruiting limit. Recruits created are written into the data base array IOCORE. One aspect of the recruiting process that is directly visible is the recruiting shortages. These are interactively communicated to the operator to allow the disposal of the shortage. Electing to obtain the predisposal ETAB table, then printing and comparing the postdisposal ETAB table will show whether this process is working correctly. In addition to the analyst's diagnostics, the program writes recruits that are created onto file 66. Note that this file is also used for the wastage created, so officers will have to be differentiated by the "SIGCH" variable

which is the last of the officer's variables to be written; 2 is used for recruitment and 4 for wastage.

Resequencing and Ageing. Ageing is done at the start of the new year process, and simply involves adding one year to each officer's years of service and time in rank. Label 30 of subroutine ANS contains the code. Resequencing is much more complex. The process is achieved in the subroutine RESEQ, and involves removing officers deemed to be wasted, moving the promotees up a rank, and introducing recruits. While it is possible to introduce diagnostics to check this process, such measures are not considered necessary, as the program has a "traps" in both subroutines IN and OUT which check for range and which invoke a stop if an error is detected. However, if a further check is required, run the model forward for a couple of years, then dump the file to a printer. A manual check of the order of the officers then is completed. Rank should be decreasing, then category increasing and, finally, time in rank decreasing. The remaining problem is "losing" individuals. This has occurred during model development; however, when it happens, a whole class of officers is usually lost. For example, if the promotees are lost (which will happen if file 23 is not connected as a random access file), then the problem will be obvious as several hundred officers will "disappear" from the

data base. Checking the normal model outputs will reveal problems such as this.

Costing. The costing report is compiled directly from the manpower data base and the cost data file. First, run the model forward for one year to generate recruits and hence training costs. Next, choose a Category to examine and obtain a printout of the cost report and the time in rank for each officer in the Category. Identify the correct salary table in the cost data file and multiply the number in each time in rank "bin" by the salary, adding these costs to obtain the cost of the Category rank cell. Repeat the process for each rank cell, then total the costs to obtain the Category costs. Obtain the report on the number of recruits to the Category from the significant change option of the Tabulate function, and multiply this cost by the training cost in the cost data file to produce the training cost. When one Category has been shown to be accurately represented, other Categories should be examined, Category totals added to produce Branch totals, etc. Generally, the process of checking the cost report is straightforward but requires a considerable amount of simple arithmetic to complete.

"Macro Checking." The foregoing discussion essentially is a description of the "micro" examination needed to verify the model. When these processes have

been completed, the analyst should examine the macro output of the model to ensure that nothing is being lost at the interface between the various program modules and functions. This process has been alluded to in the previous paragraph. The model should be run for at least one time step. At the beginning of the step, a number of reports should be printed; for example, the ETAB table and a series of reports from the Tabulate option. Concentrate on a single Category by invoking the confinement option in the Tabulate process to ensure that the internal processing of the program can be easily determined. (The ROS model always processes one Category at a time.) Next, move the model forward for a year and repeat the reporting process. Now, examine the reports for internal consistency. For example, does the initial Category strength, less wastage, plus recruits, equal the final strength? Does the progression of cohorts in each block of years of service seem reasonable? Are the promotions made in any rank consistent with the vacancies as expressed by losses and promotions from the rank, plus the change in target between the years? When the investigation of one Category is complete, one or more other Categories should be examined to ensure that the model is processing all Categories accurately. If the analyst is reluctant to make modifications to the source code (and some programming skill in FORTRAN, and in operating the host computer is required), then this

method of verification may be preferable. The author's opinion of the process is that, unless major changes in the code are made, a micro examination of the model is not necessary, as the joint power of the ETAB report, and the Tabulate function allow detailed investigation of the model processes to be made. A thorough investigation at this level by an analyst who is very familiar with the real world processes should yield a high degree of confidence that the present model is performing as intended, thus can therefore be considered "verified."

Variability of Model Output

The ROS model has previously been described as a "hybrid" in which various simulation techniques (e.g., deterministic, stochastic) are combined to provide the desired result. The majority of the processing is deterministic; predetermined rules define the outcomes. However, two processes are stochastic--wastage and promotions. Thus, when the model is run a number of times with different random number streams, different results will ensue. This effect can be observed using the "R" (= re-start) option. Indeed, this is the primary function of this option; it allows the analyst to make a new run with a different set of random numbers. When re-start is invoked, the program re-reads all the data files and starts from

year one, but does not start with the same random number seed. The result of this process is a different outcome.

A philosophical point must be made here. If it were possible to "re-run" the world a number of times, would the outcomes be the same, or would the result be different? The answer depends on a person's belief about the nature of the processes in the universe; some would argue that all processes are preordained and that re-running the world (if that were possible), would produce identical results for each run. The alternative view is that the universe is subject to the stochastic process, and that the outcome of a series of events can never be stated with certainty; only probability statements of a future event can be entertained. In this universe, re-runs would give different results, the variability depending on the underlying probability distributions that control the process. This latter view of the universe is taken here. For example, a change in an officer's state is determined as a probability that each officer will waste from the system, be promoted, or remain unchanged. The result of the stochastic process is that different runs will yield different results. If the probability distribution used in the model is the same as is present in the real world, then the assumption made is that the model will produce a valid representation of the real world processes.

An outgrowth of this concept is the method used to validate the model. The normal validation process is to make a number of observations from the real world of the process being considered, then run the model a number of times to obtain a series of results. Statistical processes are then used to test the hypothesis that the observations from the model came from the real world. Another way of looking at this process is that the results of the model are mapped onto the results observed in the real world, and if the mapping shows close agreement, then the model is said to be a valid representation of the real world. The difficulty in this study is that it is only possible to obtain a single observation from the real world; i.e., the state of the Officer Corps at any time. It is not possible to re-run the world, nor do conditions remain constant long enough to allow observations to be taken over several years (and even if it were possible, the time delay could not be tolerated). The approach taken here will be to reverse the usual validation process and map the (single) result from the real world onto the results obtained from the model. An assumption being made here is that the mapping process exhibits a transitive property; if the model has a high degree of isomorphism with the real world, and the results can be mapped accurately onto the results from the real world, then, equally well, the results of the real world can be accurately mapped onto

the results from the model. If statistical tests show that there is a high probability that the real world results could have been generated by the same processes contained in the model, then the model is considered to be a valid representation of the real world (from the transitive property that the real world is a valid representation of the model).

Independence and Linearity of Observations. A comment on the independence and linearity of observations from the model must be made. Wastage is the prime factor in generating variations in the outcomes of the model. Most other factors, such as growth, are treated deterministically. Subsequent actions, such as promotions and recruiting, will be dependent on the number of losses through wastage; thus care should be taken not to consider the variability in, say, recruiting, as an independent observation from wastage levels. Promotion has its own stochastic process, which, combined with a number of losses from wastage, can vary the number of promotions to a given rank. Consequently, the costs presented in the cost report are dependent on both wastage and promotions. A second factor is the linearity of the outcomes. The model is goal seeking and, having achieved a goal, terminates action to achieve the goal. This termination can cause nonlinearities to enter the system. For example,

consider the case where the expected result from growth and wastage creates a requirement for (say) fifty recruits. If the recruiting limit is fifty, and wastage, randomly determined is sixty, then only fifty officers will be recruited. Conversely, if randomly determined wastage is forty, only forty officers will be recruited. This example shows (with the given parameters) that, although lower than expected wastage will be tracked accurately by the number of recruits, higher wastage than expected will yield a constant number of recruits. Care should be taken that such nonlinearities do not affect the accuracy of statistical inferences drawn from the results. Generally, the Central Limit Theorem will be invoked in this study to allow statistical inferences to be drawn. (For a discussion on the Central Limit Theorem, see Mendenhall, Scheaffer, and Wackerly, 1981:275.)

Validation

The foregoing has set the stage for a description of the validation process. A suggestion is that validation should be completed each year that the model is used, to ensure that the processes in the model remain the same as those that affect the structure of the Officer Corps in the real world. An important point to understand is that the validity of a model cannot be proven; there are only degrees of validity. The usefulness of the concept of

validity is that it provides a measure of the usefulness of the model. If validation studies show that the model is not sufficiently accurate to be useful (e.g., the model does not make sufficiently accurate predictions), then amendments will have to be made to the model, requiring the process of verification and validation to be repeated. Most models are developed in this iterative fashion, and the ROS model is no exception; many segments of the model have been changed after the output has been compared with the "real world." Completion of the validation process by the analyst should demonstrate the model's ability to predict the future and, in doing so, increase the analyst's confidence in the model. These two factors are considered to be the prime reason for the validation, since the model will not be used unless it can be shown that it is sufficiently accurate, giving users confidence in it.

Turing Test. Shannon (1979:216), suggests that one method of validation is the "Turing" test. In this test, an "expert" in the field is presented with a series of results taken from both the model and the real world. If the expert cannot tell the difference between the outputs, then the model is assumed to be valid. This is a behaviorally oriented test that is useful as a first attempt at validation, since rigorous and hence time-consuming activities (such as those described here) are

not necessary. The ROS model has already been exposed to this process, and the usefulness of the techniques has been demonstrated as the test has shown errors in the coding of the simulation and in the basic processes within the model; many improvements have consequently been incorporated.

At the other end of the scale (if a scale from highly technical to highly behavioral is envisaged), goodness of fit tests can be used to obtain a measure of model validity. The remainder of this chapter describes a strategy that can be used to generate a goodness of fit test. In essence, the methodology is to observe one time step in the real world, then map as many of the variables observed in the real world during that step, back into the model. The model can then be run several times and estimates obtained of the mean and standard deviation of the output. If the single result obtained from the real world can be shown to have come from the same distribution as the model demonstrates, then the model, by the transitive process described above, is assumed to be a valid representation of the real world.

Before describing the validation strategy in detail, some comments on the interdependence of the various model outputs will be made. Normally, dependence is considered to be a nuisance that must be allowed for. In this validation strategy, dependence can be used as an

asset to further test the internal relationships in the model. Wastage observed is the only independent variable; all other observations are dependent on wastage or other processes in the model. If the statistical test shows that there is a reasonable probability that the real world and the model wastage comes from the same distribution, then the sets of dependent variables should be examined for correspondence. Examples are promotions, recruitment, years of service structure, etc. If both chains of dependent variables are the same (within the statistical confidence intervals), then this increases the user's confidence that the internal processing of the model is similar to the processing that occurs in the real world.

Turning now to the validation strategy, the first step is to select a period for observation. A good time to start is the state of the Officer Corps at 1 January, which is the time when all promotions have taken effect, and the majority of officer cadets have been commissioned. The model output should be examined in detail, and the data sets that "feed" the model should be used to determine the processes to be recorded. Examples are the Establishment, Authorized Terminal Strength, actual manpower on the date, and all the information contained in the establishment, system, and cost files. As the year progresses, a data base of the year's events should be

compiled. Finally, the state of the Officer Corps at the end of the year should be recorded.

Armed with this data, the next step for the analyst is to create the four new data files, namely manpower, establishment, system, and cost, making every effort to have these files match the events that occurred during the immediate past year. As an example, the recruiting constraints should be set to match the real world situation; if recruiting was difficult in a Category, an estimate of the constraint should be made; alternatively, if recruiting was relatively easy, the analyst should set the constraint higher than the results achieved.

When the analyst is confident that the model data files contain the best estimate of the immediate past real world events, the model should be run for one time step, using these new data files. Several runs should be made, using the "R" restart option to generate different results. During each run, the correct Authorized Terminal Strength should be used, and the appropriate responses to the reallocation of recruiting shortages made. At the end of each run, reports should be printed to allow comparison with the real world result. As a suggestion, at least five runs should be made, to allow reasonably accurate estimates of the mean and standard deviation to be struck. Typical printouts would be the ETAB and cost tables, the model summary reports, and reports from the Tabulate

option. The analyst should decide before the runs the variables to be examined, then request the necessary reports.

When an estimate of the mean and standard deviation has been obtained, the result from the real world should be examined to determine the probability of it coming from the distribution exhibited by the model. The null hypothesis is that the real world and the model have the same underlying distribution, while the alternate is that they are different. If it is not possible to reject the null hypothesis on the basis of the probability obtained above, then the null hypothesis is accepted. The testing process is continued through the chain of dependent variables. If good agreement is obtained throughout the chain, then the model is considered to be a valid representation of the real world.

In the event of poor agreement, further investigation is required. The first step is to reexamine all the model's data files to ensure that they are the best estimate of the real world events. Some skill in using a single variable to represent an entire year's events in a specific area is required. (Improvements of the analyst's skill at this representation will assist the estimating process when predictions are to be made.) If the data files are considered accurate, the analyst should next examine the functioning of the model to ensure that the verification

was accurate. Finally, the way the model represents the real world should be examined and, if shortcomings are revealed, a new iteration of model development initiated. Thus, if the model fails its validation test, the data obtained from the validation process should be used to develop the model. In this way, closure on a sufficiently accurate (i.e., valid) model may be obtained.

Once the model has been validated (i.e., the analyst and users have confidence that it will predict with useful accuracy), a new set of data files should be created. These must use the present manpower data base, plus best estimates of the model parameters (e.g., recruiting constraints) for the prediction period. The model should then be run to generate the predictions, again using the "R" option to simulate the variety of outcomes and accumulating the results of the runs to allow statistical inferences to be drawn about the expected future structure of the Officer Corps.

Summary

This chapter has dealt with the issue of validation of the model, validation being defined as a process in which confidence is built in the model's ability to generate predictions that have sufficient accuracy to be useful. The validation process was segmented into a verification process where the accuracy of the program is

evaluated, and a validation process in which the results from the real world are mapped onto the results from the model; validation being demonstrated by a high degree of correspondence between the two. This process is the reverse of the normal process where the results of the model are mapped onto the results from the real world. However, the constraint of only being able to obtain a single observation from the real world is the reason for this approach. To support the validation method, detailed comments on the variability of the results obtained from both the real world and the model were made.

Chapter 8

EXAMPLES OF THE USE OF THE RAAF OFFICER STRUCTURE MODEL

Introduction

The purpose of this chapter is to provide examples of the operational use of the Royal Australian Air Force (RAAF) Officer Structure (ROS) model. The primary purpose of the model is to largely automate the strength management of the Officer Corps. However, the model may be used for other purposes, and some of these will be demonstrated later in this chapter.

Demonstration Data. To initially implement the model and provide examples of its use, demonstration data has been provided. Readers should be aware that this data base, while having been derived from "real" data, has been altered substantially (primarily for security reasons). Thus, care should be taken that no inferences be drawn about the RAAF from the following examples of the model's use. Notwithstanding the foregoing, the demonstration data base has been constructed to be representative of the way that the model will be used to solve "real world" problems.

Using the Model for Long-Range Strength Management

The primary use for the ROS model is strength management, taking account of a number of factors which may influence the strength of the Service over several years. Accordingly, this will be the first demonstration of the use of the model. Several simulation runs will be made, with the results from each run being used to move nearer to the objective on the next run. This iterative planning method was described in Chapter 4. The aim of this exercise is to produce a long-term policy for strength management and to identify programs (such as building facilities) needed to support the Officer Corps.

The Scenario. In Chapter 2, the problem of a different Establishment size and Authorized Terminal Strength was described. The effect of this mismatch is to create a large number of positions that cannot be filled, even if the Service is at the authorized strength. For example, in the first year (1981) of the demonstration data base, the Establishment size is 3899 and the Authorized Terminal Strength is 3650, a shortfall of 249 positions. Such shortages tend to interfere with the organization as lines of communication are broken, and the duties of a vacant position are shared amongst the authorized positions. By contrast, the strength of the RAAF Officer Corps (as shown in the data base) is 3647, i.e., very close to the

Authorized Terminal Strength. The task given to the Personnel Divisions (for this demonstration) is as follows:

Given that the Establishment will be held to 4000 by 1 January 1990, take the necessary measures to make the strength of the Officer Corps match the Establishment by that date. Assume that, starting from 1 January 1981, a growth of 50 officer positions per year will be authorized. Try to keep the Category strength in balance with the decision rules for strength allocation by avoiding over-recruiting. Control measures such as wastage reduction, providing additional facilities, and expanding recruiting or training may be used. If possible, avoid large changes in the Establishment. Finally, try to keep the strength as close to the Authorized Terminal Strength as possible; if recruiting shortfalls occur, allocate deficiency evenly to the Equipment and Administrative Categories, ensuring that the maximum amount of recruitment above target is 20.

Run Number One: Master Run (No Variations). The "master" run is made to determine the base line situation. In this run, the data base contains all the original data sets, based on present expectations and planned actions. During the run, the recruiting shortfalls are printed out at the terminal being used by the operator of the model. These shortfalls provide an excellent surrogate to

determine the performance of the strength management process; if no strength shortfalls are present, then the model is achieving the task set by the operator. The results of the run are summarized in Figure 8.1. Using recruiting shortfalls as the measure of performance, the model predicts that a deficiency of about 110 per year will be the expected result, with a peak deficiency of almost 130 in 1988. Given that the strength was initially close to the Authorized Terminal Strength, this is a disappointing result, since it shows that even without growth, the Service will be unable to even maintain its present strength. The most serious shortages are in the Navigator, Aeronautical, Radio, Armament, Instrument and Doctor Categories. Some initial shortages are observed in the Intelligence Category; however, by 1987 these have been brought under control. The remainder of the Categories seem to be able to sustain their allocated strength.

Run Number Two: Wastage Reduction. In Chapter 2, wastage of officers was cited as the most important factor in creating a Service of the desired quality and structure, hence this is the first area to examine. Wastage rates can be changed by many factors, some within the control of Personnel Division. Posting policies (such as the frequency of movements of location), appointment policy, career counseling, observing individual officer's

Predicted Category Shortages: Master Run								
Category/1 Jan:	83	84	85	86	87	88	89	90
Pilot								
Navigator	41	37	34	36	32	31	24	20
Aeronautical	12	18	19	28	34	31	43	42
Radio	14	13	10	14	20	22	11	11
Armament	2	1		4	9	10	6	8
Instrument			1	2		5	4	
Electrical								
Equipment			1					
Works	4							
Administrative								
Air Traffic								
Air Defence								2
Intelligence	11	9	9	3				
Education								
Ground Defence						1	3	2
Photographic								
Police	1							
Legal								
Doctor	16	16	17	17	19	27	27	23
Dentist								
Nurse								
Pharmaceutical								
Radiographer								
Laboratory								
Hygiene								
TOTAL:	101	94	91	104	114	127	118	108

Fig. 8.1 Recruiting Shortages by Category and Year as at 1 January

preferences, all affect the wastage rate. Generally, such policies favor the individual at the expense of the Service in the short term, with the objective of increasing the strength and experience of the Officer Corps, thereby improving the capability of the Service in the long term. A second method of adjusting the wastage rate is to change the remuneration for Serving Officers. If, for example, salaries and allowances are raised, the Service will compare more favorably with the remuneration received by civilians and lower wastage is the likely result. (A second effect is that more civilians will volunteer for service; this will be discussed in the next paragraph.) Assume that all practical measures are taken to reduce wastage, and the best estimate is that wastage rates will generally drop by 15 percent as a result. (As a comment, at the time of this writing, the Australian Armed Services had just received a substantial pay rise. The wastage rates in the present data base were for the prior salary scales; accordingly, reduction of wastage as a strength control measure is quite realistic and topical.) The ROS model is now run with reduced wastage rates. Assume that until 1990, the combined effect of personnel and pay policies are estimated to reduce wastage by 15 percent, or to 0.85 of its former value. (The transform between a pay rise and wastage reduction could be estimated by analysis of the effects of prior pay rises on the wastage rates,

assuming such data are available; alternatively, an "expert" opinion could be sought. In any case, the direction of the effect of a pay rise on wastage rates would be known, since a rise in salary is unlikely to result in a general rise in wastage rates.) The operator communicates this state to the model when asked for the "wastage factor" at the beginning of each year in the simulation. All other parameters are held constant. The results of this action are shown in Figure 8.2. The reduction in wastage has resulted in a reduction of about 60 in recruiting shortfalls. The Navigator Category has now come under control, meeting strength targets by 1988. However, problems remain in the Engineer Branch and the Doctor Category.

Run Number Three: Wastage Reduction plus Growth.

Although the strength has not been brought entirely under control by wastage reduction, the strength improvement of about 60 per annum can be used to allow the planned growth of about 50 per annum, as called for by the scenario. This situation is investigated in run three, when the Authorized Terminal Strength is increased by 50 per annum, until the ultimate strength target of 4000 is achieved in 1988; the Authorized Terminal Strength is held constant thereafter. The operator nominates the Authorized Terminal Strength for the coming year at each annual step of the model. Incorporating both wastage reduction and growth,

Predicted Category Shortages: Wastage Reduction								
Category/1 Jan:	83	84	85	86	87	88	89	90
Pilot								
Navigator	33	24	17	11	6			
Aeronautical				8	10	15	12	18
Radio	7	1		5	1	4		
Armament	6	3						
Instrument		1		3	9	10	12	10
Electrical							1	1
Equipment	2							
Works								
Administrative								
Air Traffic								
Air Defence								
Intelligence	8	3						
Education								
Ground Defence		1						
Photographic								
Police								
Legal								
Doctor	17	17	17	18	17	17	17	18
Dentist								
Nurse								
Pharmaceutical								
Radiographer								
Laboratory								
Hygiene								
TOTAL:	73	50	34	45	43	46	42	47

Fig. 8.2 Recruiting Shortages by Category and Year as at 1 January

the results are shown in Figure 8.3. As expected, the growth has largely offset the improvements won through the wastage reduction, with the net result being an average shortfall in strength of about 100 per year. The Navigator Category has remained under control, while the Equipment Category now shows deficiencies, along with the Engineering Branch and the Doctor Category. The reason for this effect can be found in the strength allocation rules. Increasing the Authorized Terminal Strength has the secondary effect of increasing the strength of those Categories that were not previously 100 percent manned. Recall that the Navigator Category, being part of the General Duties Branch, is allocated a strength that is 100 percent of its Establishment. Thus, wastage reduction will ease the manning problem, while growth will leave it unaffected, assuming its Establishment is unchanged. By contrast, in the Equipment Category, wastage reduction also eases the manning problem, but any growth will create a demand for additional recruits to fill the new positions allocated as the allocation of the Authorized Terminal Strength to this Category rises. In this demonstration run, this effect has resulted in the Category going "out of control"; i.e., it is no longer possible to maintain the strength through recruiting, as the model calls for more recruits than are allowed for by the system data recruiting constraints. This result is a good demonstration of the interaction of

Predicted Category Shortages: Reduce Wastage + Growth								
Category/1 Jan:	83	84	85	86	87	88	89	90
Pilot								
Navigator	34	25	19	9	3			
Aeronautical	4	15	16	16	19	27	34	38
Radio	17	14	14	21	22	23	21	23
Armament	8	7	6	6	3	4	1	
Instrument		5	9	6	13	18	14	12
Electrical								
Equipment			10	24	13	32	18	12
Works	4							
Administrative								
Air Traffic			7					
Air Defence	1					1		
Intelligence	11	7	5	3	1			
Education								
Ground Defence						2		
Photographic								
Police								
Legal								
Doctor	19	19	21	21	23	22	21	22
Dentist								
Nurse								
Pharmaceutical								
Radiographer								
Laboratory								
Hygiene								
TOTAL:	98	93	107	106	97	129	109	107

Fig. 8.3 Recruiting Shortages by Category and Year as at 1 January

different constraints and inputs; the result obtained is easily understood, but may not have been intuitively obvious before the model was run. Furthermore, determining the result of the interaction of wastage and growth would have been a very difficult manual task.

Run Number Four: Incrementing Recruiting Limits.

If the wastage reduction and growth are maintained as in run number three, the target of 4000 officers by 1990 will not be achieved without some additional action. The next area to investigate is lifting recruiting constraints since the model will achieve strength targets by introducing junior officers to offset deficiencies in the senior ranks, if required. Although the Establishment will not be perfectly matched within a rank, at least the correct number of officers will be available to fill all the Category positions (e.g., with acting rank, or by receiving higher duties allowances). Expanding the recruiting constraints requires the combination of a number of different actions as described above. For example, new facilities could be built, or existing facilities converted for training purposes. In some Categories, additional officer cadets can be recruited to eventually enter the Officer Corps. Most efforts to increase recruiting will take several years to take effect. For example, the results of increasing the cadet intake of (say) Engineers into a

four-year course will not be felt until a delay of five years; four years for the course and usually one year to make the decision and initiate the increased recruiting rate. In run four, increments in the recruiting rate have been made to simulate these considerations; these increments are shown in Figure 8.4. Note that the increment for the Equipment Category starts in 1983, since there is not a long training course involved, while increments for the Engineer Branch are delayed until 1986. The lack of changes in the Doctor Category reflects a limit on the number of civilians who will volunteer for service in the RAAF, and is included as an example of a Category where the ultimate limit is set by the rate that volunteers can be obtained from the community. To effect changes of recruiting constraints, the "maximum recruits" entries in the system data file must be amended with the increments shown in Figure 8.4. The results are presented in Figure 8.5. As expected, the increase in the maximum recruiting rates has had the desired effect, and the shortfall now averages only 40, with the shortfall being only four in 1990. The most encouraging result is the trend; the lifting of recruiting constraints results in steady inroads into the recruiting shortfall, with the strength effectively coming under control by 1 January 1986, when shortfalls are only about 20 in 4000.

Recruiting Increments to Offset Shortages								
Category/1 Jan:	83	84	85	86	87	88	89	90
Pilot								
Navigator								
Aeronautical				10	10	10	15	20
Radio				10	10	10	15	20
Armament				2	2	2	2	2
Instrument				5	5	10	10	10
Electrical								
Equipment		10	15	15	20	20	20	20
Works								
Administrative								
Air Traffic								
Air Defence								
Intelligence								
Education								
Ground Defence								
Photographic								
Police								
Legal								
Doctor			5	5	5	5	5	5
Dentist								
Nurse								
Pharmaceutical								
Radiographer								
Laboratory								
Hygiene								
TOTAL:		10	20	47	52	57	67	77

Fig. 8.4 Recruiting Shortages by Category and Year as at 1 January

Predicted Category Shortages: Red Waste, Growth, Rec Inc								
Category/1 Jan:	83	84	85	86	87	88	89	90
Pilot								
Navigator	34	25	17	11			6	4
Aeronautical	4	15	5			1		
Radio	17	14	5		2			
Armament	8	7	3					
Instrument		5	4					
Electrical					2	4		
Equipment								
Works	4							
Administrative								
Air Traffic			7			1	2	
Air Defence	1						1	
Intelligence	11		4	1	5	4		
Education								
Ground Defence		1				2	1	
Photographic					1			
Police								
Legal								
Doctor	19	18	15	9	5	5	3	
Dentist								
Nurse								
Pharmaceutical								
Radiographer								
Laboratory								
Hygiene								
TOTAL:	98	92	60	21	14	17	13	4

Fig. 8.5 Recruiting Shortages by Category
and Year as at 1 January

Run Number Five: Establishment Variations. At

this stage, Personnel Division has probably exhausted all the possibilities for internal action and must seek external help to achieve the objective. In run five, some "fine tuning" of the Officer Corps strength is made by making variations to the Establishment. Minor changes are often possible, as there are many officer positions that can be filled by officers from several Categories. (In fact, this is the current trend in the RAAF, whenever possible, officer positions are established with as many source Categories as possible, as this greatly eases the manning problem.) In Figure 8.6, variations to the Establishment are made to provide the capability required. Some of the Navigator Category positions are transferred to the Pilot Category, while a number of Engineer Branch positions are transferred to the Equipment Category, which in run four was brought under control by substantially increasing the number of recruits that could be introduced into that Category. In addition, minor changes have been made to other Categories: Administrative, Air Traffic, and Education. The increments in the Education Category would reflect an increase in training requirements as a result of the greatly increased number of recruits. For the Doctor Category, a steady decrease of four per year for the years 1985 to 1990 is shown; such a change could result from a policy decision to make more use of local

Establishment Variations. (for the Year Preceding:)								
Category/1 Jan:	83	84	85	86	87	88	89	90
Pilot		5	5	5				
Navigator		-5	-5					
Aeronautical		-5						
Radio		-5						
Armament		-5						
Instrument								
Electrical		-2						
Equipment		3	5	5	5	4		
Works								
Administrative		6	6					
Air Traffic			4					
Air Defence								
Intelligence								
Education		7	8					
Ground Defence								
Photographic								
Police								
Legal								
Doctor			-4	-4	-4	-4	-4	-4
Dentist								
Nurse								
Pharmaceutical								
Radiographer								
Laboratory								
Hygiene								
TOTAL:	0	-1	19	6	-4	-4	-4	-4

Fig. 8.6 Establishment Changes by Category and Year as at 1 January

civilian medical facilities, thereby reducing the number of Service Doctors required. These changes are applied to the increment section of the Establishment data file. The results of the run are shown in Figure 8.7. Note that both the Authorized Terminal Strength and the Establishment have now been brought to 4000 as in the scenario. The net result of the changes is to reduce the average deficiency to 30. Again, the trend is very encouraging, with insignificant variations from the growth plan after 1 January 1986.

Run Number Six: Allocation of Recruiting Shortfalls. Strength targets would rarely be achieved if recruiting were stopped when the target in any Category was reached. The practice in Personnel Division is to offset underachievements in one Category by over-recruiting in other Categories where recruiting constraints allow. The purpose of this action is to take maximum advantage of the authorized strength. However, the practice is not desirable, as sustained over-recruiting leads to "bulges" in the Category strength that can at a later stage give problems with structure. If, for example, a large number of recruits are forced onto a Category for several years, a "bulge" or strength wave will pass through the Category. Those officers at the peak of the wave will face strong competition for promotion. Behind the wave,

Predicted Category Shortages: Establishment Variations								
Category/1 Jan:	83	84	85	86	87	88	89	90
Pilot								
Navigator	34	20	13	3				
Aeronautical	4	10	3					
Radio	17	9	4					
Armament	8	2						
Instrument		5	2					
Electrical				1		1		
Equipment			2					
Works	4							
Administrative								
Air Traffic			3					
Air Defence	1					3	4	3
Intelligence	11	7	3					
Education		4						
Ground Defence		1			1	2		
Photographic								
Police								
Legal								
Doctor	19	18	12	5				
Dentist								
Nurse								
Pharmaceutical								
Radiographer								
Laboratory								
Hygiene								
TOTAL:	98	76	42	9	1	6	4	3

Fig. 8.7 Recruiting Shortages by Category and Year as at 1 January

a strength rarefaction will occur as the strength management system seeks to restore the Category to its correct strength according to its share of the Authorized Terminal Strength. The recruiting system will slow down, creating discontinuities in the training system, and Personnel Division finds that the number of officers available for promotion may be so small that promotion vacancies cannot be filled. For these reasons, over-recruiting is seen as a last resort, and must be used only at the rate that the Category can absorb, hence the limit of 20 placed on the over-recruiting in the scenario. Figure 8.8 shows the result of introducing over-recruiting into the Equipment and Administrative Categories. The negative entries show the over-recruiting, and the positive, the recruiting shortfalls. Even with a limit of 20 on the over-recruiting, the strength management system now has almost complete control, with the strength targets being achieved by 1 January 1985, a consequent average strength shortfall of only 9.5, and no strength deficiencies from 1 January 1985. This is the desired result. Establishment, target, and strength have been made to match, with growth to 4000 being achieved by 1 January 1990 as requested.

Summary. A strength management policy has now been evolved from the direction given in the scenario printed above. In summary, the policy is:

Predicted Category Shortages: Final, Recruit. Variations								
Category/1 Jan:	83	84	85	86	87	88	89	90
Pilot								
Navigator	34	20	7					
Aeronautical	4	1						
Radio	17	12	7	6	7			
Armament	8	1	1					3
Instrument								
Electrical								
Equipment	-20	-20	-11	-3	-5	-1	-1	-2
Works	5							
Administrative	-20	-20	-11	-3	-4			-2
Air Traffic								
Air Defence							1	1
Intelligence	12	7	3					
Education		2						
Ground Defence					2	1		
Photographic								
Police	2	1						
Legal								
Doctor	19	11	4					
Dentist								
Nurse								
Pharmaceutical								
Radiographer								
Laboratory								
Hygiene								
TOTAL:	61	15	0	0	0	0	0	0

Fig. 8.8 Recruiting Shortages by Category and Year as at 1 January

1. Reduce wastage by 15 percent.
2. Increment recruiting capability as shown in Figure 8.4. The main changes are significant increases in the recruiting rates of the Engineer Branch, the Equipment Category, and the Doctor Category.
3. Minor changes are required to some Categories. In summary, the Pilot Category is increased at the expense of the Navigator Category; the Equipment and the Administrative Categories are increased to accept positions from the Engineer Branch. The Education Category is increased to assist training the larger number of new recruits, while the Doctor Category is reduced as a result of a policy change on the use of civilian medical facilities.
4. Over-recruiting with an annual limit of 20 above target into the Equipment and Administrative Categories is authorized.

An Examination of Strength
versus Years of Service

One of the most interesting and enlightening studies of the structure of an organization such as the Royal Australian Air Force is an examination of strength versus years of service. One way to present this information is to sort officers into "bins" of years of service

(e.g., 0 to 1, 1 to 2, etc.), then plot the number in each bin versus the years of service. The "correct" way to present this figure is in histogram form; however, a more convenient method is to simply join the strength levels to each other.

Figure 8.9 shows such a plot. In this figure, the results from run six, the final run which produced the desired strength management plan, have been used. The reason for using the final run is that policy decisions affect the number of recruits in each year; thus it is best to use a run based on the policy which has the greatest likelihood of being implemented. Two plots of strength versus years of service have been used: one for 1 January 1982, and one for 1 January 1990, i.e., the beginning and end of the simulation run. Overlaying the two plots allows comparisons to be made. Note that the plots have had a linear regression of strength versus years of service overlayed on them.

Taking the 1 January 1982 plot first, note that there are a number of peaks and valleys in the graph. Perhaps the most significant is the peak at about the 16 to 17 years of service level. This peak was caused by increased recruiting rates during the Vietnam conflict, where the Royal Australian Air Force provided a number of Units for overseas duty. After the conflict ended, strength requirements were lower than the force in being

ROYAL AUSTRALIAN AIR FORCE OFFICER CORPS

Strength versus Years of Service for 1982 and 1990

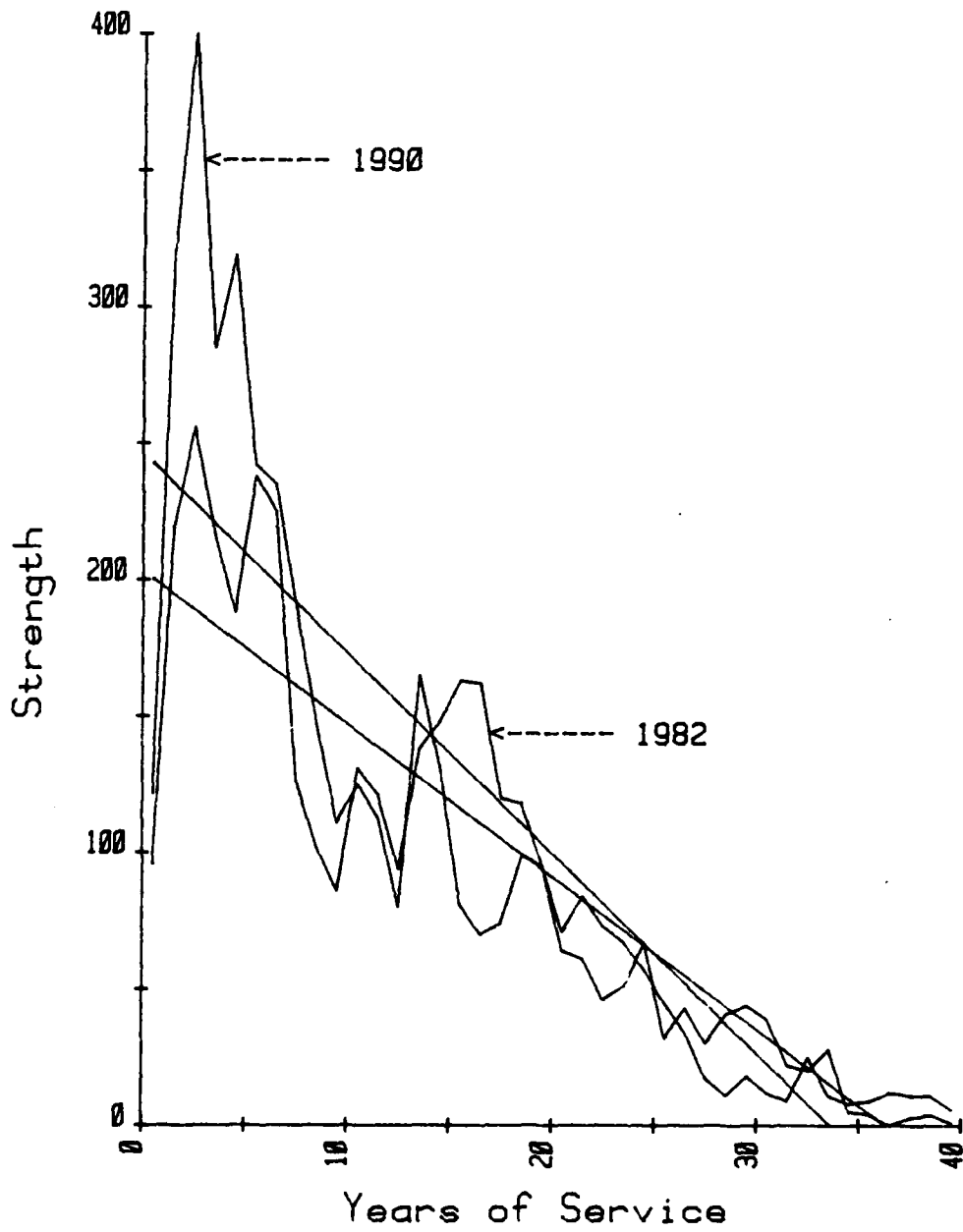


Fig. 8.9 Strength versus Years of Service for 1982 and 1990

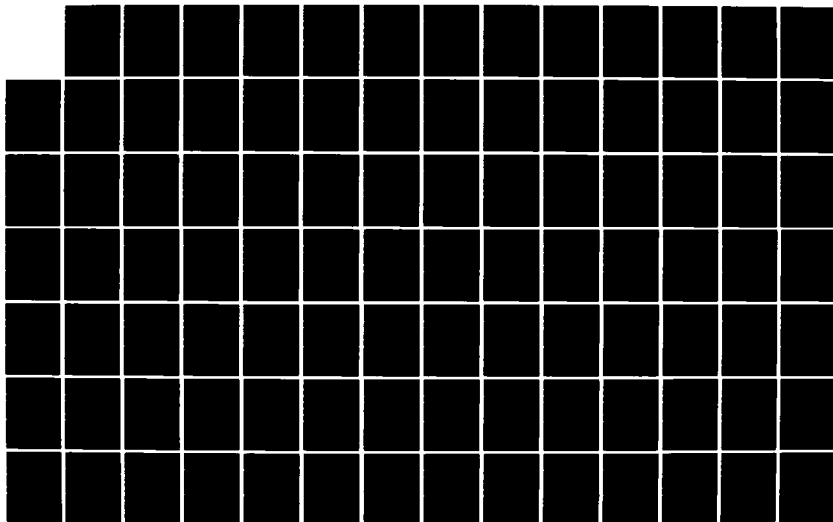
AD-A122 847

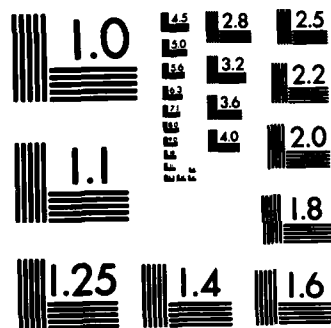
A COMPUTER SIMULATION OF THE STRUCTURE OF THE ROYAL
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and, as a result, recruiting rates were heavily cut. When the force had dwindled to the required size, recruiting rates were returned to their normal level. All this can be seen from the plot at Figure 8.9 and clearly shows one of the major problems with strength management. When a short-term "step" in strength is required in order to service the demands of a conflict, the resultant recruiting rate will be greatly increased, then decreased below the rate required to service just the losses experienced through wastage. Such wild oscillations place severe loads on the recruiting and training system. An important secondary effect is usually noted in volunteer forces: variations in the quality of recruits. Assuming a reasonably constant application rate, increasing the recruiting rate inevitably decreases the quality of recruits and vice versa. Thus, there may well be "quality waves" as well as strength waves in the organization; these waves will be 180 degrees out of phase with the strength waves. A common error in reducing the strength after a conflict, is to adjust strength by adjusting the recruiting rates; this action can leave large numbers of lower quality personnel in place, while higher quality personnel are denied entry. One solution to this problem is to recruit for a conflict on the basis that most of the positions offered will be temporary; then after the conflict, reduce strength by discharging the lower quality temporary personnel. In

this way, the quality of the Corps can be maintained at an even level and the strength quickly reduced after the conflict has ended. Furthermore, after the initial build-up, the load on the recruiting and training systems can be maintained approximately constant. Use of simulation models such as ROS allows the necessary actions to be predetermined.

The plot of strength versus years of service for 1990 shows a tertiary, a potentially very serious problem resulting from the high recruiting rates during the Vietnam conflict, and the subsequent failure to reduce strength by reducing some of those officers recruited during that time.

The Royal Australian Air Force, like the Armed Services of the United States, has a twenty-year pension scheme, but there is an additional factor; there is no "up or out" promotion policy in the Australian Armed Services, with the result that an officer has no impediment to reaching 20 years of service, and many do. Very few officers leave the Service between 15 and 20 years of service; in fact, the wastage rate used in the system data file for these years is about 2.5 percent per annum. By contrast, the wastage rate for officers in their twentieth year of service is about 40 percent! After twenty years of service, the wastage rate remains high. (These wastage rates can be seen in the appropriate section

of the system data file.) Thus, for a large group of officers in the Vietnam conflict peak, wastage rates for the entire Service will be initially low; then as they achieve 20 years of service, the wastage rate will be higher than normal. If left unchecked, this tertiary effect will result in markedly changed recruiting rates which is unsatisfactory for the reasons given above. If the Service is seeking to increase strength during the high wastage period, the problem is, of course, compounded. Since this is the case in the scenario chosen, high recruiting rates result, and these can be seen in the plot. Although the actual peak recruiting rate is slightly below 400, officers entering the Service with some years of service give a peak strength of 400 officers and 2 to 3 years of service for the 1990 plot.

Some conclusions can be drawn from the two plots in Figure 8.9. Regression lines have been drawn for each year. For 1982, the regression line is between a strength of 203 at zero years of service and strength of zero at 36.3 years of service, while (only) eight years later the regression line for 1990 runs from a strength of 246.4 at zero years of service to a strength of zero at 33.6 years of service. The regression coefficients for the two plots are -0.88 for 1982, and -0.85 for 1990. Although at first glance the variation may not seem to be significant, the opposite is the case. Service organizations

tend to be rather conservative in nature, and even small changes can produce subjectively large results. The predictions made by the model are that the average Royal Australian Air Force Officer will become considerably younger over the next eight years. In addition, the recruiting and training system will have to greatly increase its output if it is not to become the constraint on the strength of the Air Force.

The dynamics of the Officer Corps are particularly interesting. Using the output from run six, a three-dimensional plot of calendar year versus years of service versus strength has been produced, and is shown at Figure 8.10. Ignore for the moment the peaks below about ten years of service. The peaks evident in the 1 January 1982 strength versus years of service plot can be seen at the edge of the plot farthest from the viewer. As time advances, these peaks can be seen to "march" forward as expected. Of particular interest is the peak caused by the Vietnam conflict. As the peak reaches and passes the twenty years of service point, where officers are eligible for a pension, the high wastage rates in this time zone cause the peak to "melt" away, leaving a shallow gradient. At the same time, the high losses, combined with the (scenario) requirement for a strength growth of 50 officers per year, leads to greatly increased recruiting rates. Although this is not as clear in Figure 8.10 as the

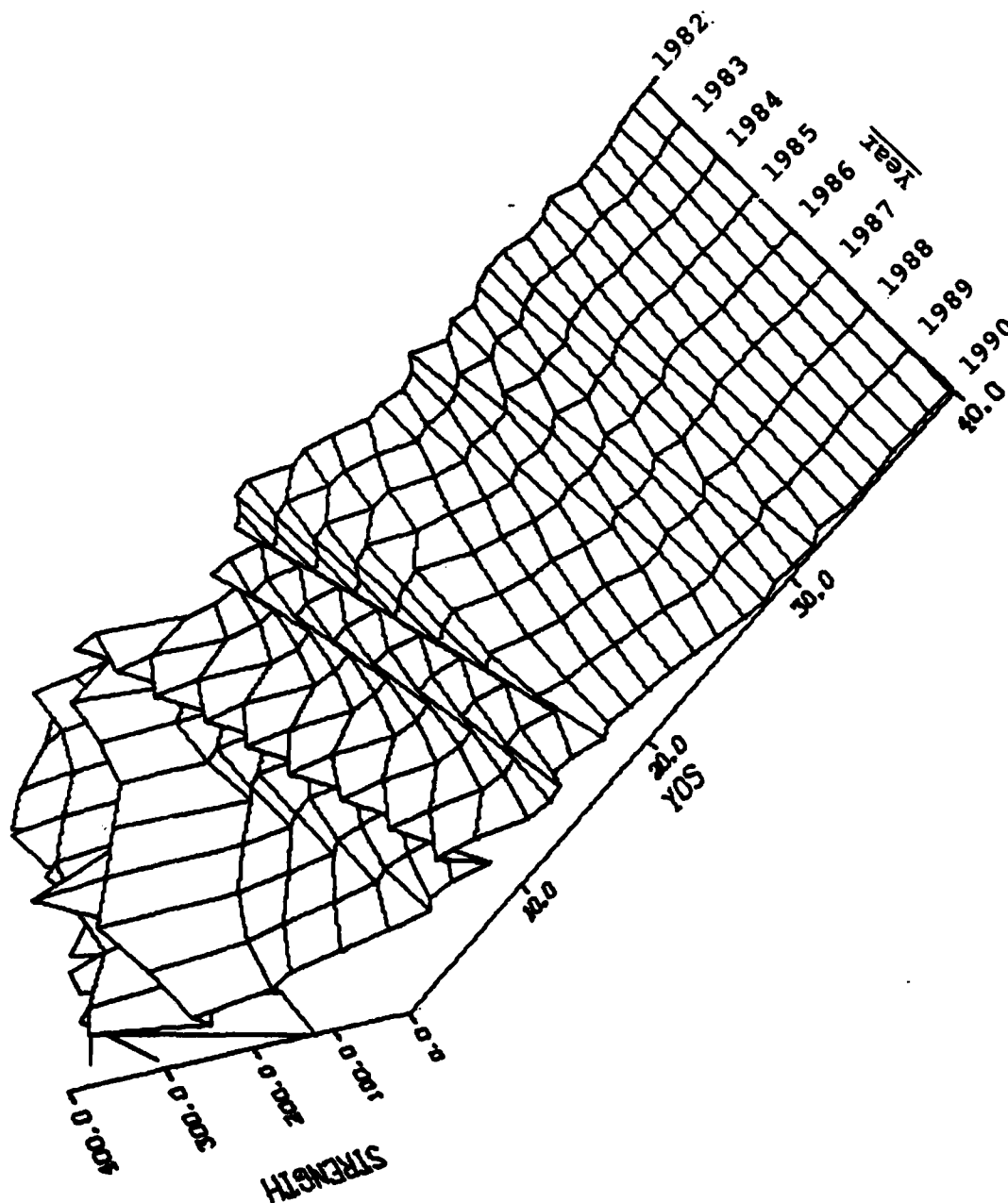


Fig. 8.10 Years of Service versus
Years versus Strength

movement of the waves, reference to the 1 January 1990 plot shown in Figure 8.9 reveals the increase in the last year.

In summary, plots of strength versus years of service tell a good deal about the structure of an organization. Given that loss of strength is inevitable, the shape of the plot is expected to be triangular, with strength declining as years of service increase. In a perfectly controlled organization, the decline will follow a predetermined pattern, generally reasonably regular in shape, as this allows the organization to enjoy steady recruiting and training rates, a constant recruit quality, and subsequent high levels of certainty as far as quality and number of eligible officers when promotions are required. Such a state produces minimal demands on those responsible for strength management. The "real world," by contrast, introduces factors which distort the structure from the ideal state. The vagaries of international politics and economics create changing demands for (military) organizations. When a strength disturbance such as a sustained conflict enters the organization, the recruiting system must first increase its output above normal, then drop below the usual rate to accommodate the change. Thus, demand for strength changes often introduces a kind of "whiplash" effect that exaggerates the effect of the change. Great care must be taken to minimize the effects

of such a whiplash. Use of models such as ROS allows planners to estimate the effects of strength changes, then try a different method of minimizing the adverse effects "a priori" by testing plans with the simulation model. Given that mistakes in personnel planning can take at least twenty years to eliminate, this method of testing policy alone gives sufficient reason to introduce and maintain a simulation model such as ROS.

Recruiting Requirements

An important piece of information resulting from the scenario described above is the recruiting rate, for this information can be used for long-range plans regarding the resources to allocate to the recruiting and ultimately the training sections of the Service. This information is readily obtainable from the "Tabulate" function of the ROS model. After the model has been advanced for at least a year, and the operator is offered the choice of actions as described in Chapter 5, the option "T" for "Tabulate" is selected. Once in this mode, the operator elects to tabulate on Category (selection 3), obtain the subset of "significant change indicator" (selection 5), and confine the significant changes to a significant change indicator of "2," which is the marker for an officer who has been recruited during the year. This may seem a little obscure, but the model provides the necessary

prompts, and the use of the Tabulate mode is simpler in operation than the description suggests. This selection example again shows the power and flexibility of this part of the model.

The recruiting requirements resulting from the satisfactory (from a strength management point of view) final "run six" of the model, using the Tabulate function, are included at Figure 8.11. For comparison, the recruiting limits, extracted from the system data file, are included at Figure 8.12. The figures presented represent the required recruiting or recruiting limit, as appropriate, for the year prior to the given date. Note that the results are for a single run of the model, and thus other runs may give slightly different results as a result of the stochastic nature of the model. (See Chapter 7 for a discussion of variability in model output.) Despite this factor, such a run can produce very interesting results. The model cannot look ahead and is thus "reactive" to the state of the structure in any year. Thus, the number of recruits required for a Category in a year will depend on the number of officers who waste from the Category and on the growth, constrained at an upper bound by recruiting limits. As described previously, the operator may also choose to force more recruits on a particular Category, in order to eliminate overall strength shortfalls that result from under-recruiting in another Category.

Recruiting Requirements for the Year Preceding:								
Category/1 Jan:	83	84	85	86	87	88	89	90
Pilot	60	41	26	29	45	55	58	59
Navigator	30	30	30	30	26	30	23	25
Aeronautical	20	20	30	27	26	35	30	33
Radio	25	25	35	35	29	35	24	35
Armament	7	8	10	9	6	6	10	10
Instrument	4	8	12	8	13	11	5	3
Electrical	2	7	7	8	8	8	8	6
Equipment	45	46	59	43	42	52	35	35
Works	5	6	3	4	4	4	3	0
Administrative	22	34	26	24	37	35	38	19
Air Traffic	17	23	24	28	32	34	23	25
Air Defence	8	9	6	4	7	9	9	7
Intelligence	9	9	9	9	9	9	2	9
Education	4	15	9	5	17	11	6	7
Ground Defence	5	3	5	5	4	2	4	5
Photographic	2	1	1	4	2	1	3	2
Police	5	5	2	0	2	4	2	1
Legal	0	2	1	1	0	1	0	1
Doctor	9	10	10	10	10	10	10	10
Dentist	4	5	3	8	9	10	4	4
Nurse	2	14	17	14	18	8	12	11
Pharmaceutical	2	1	0	2	0	1	0	2
Radiographer	1	2	1	0	0	2	0	0
Laboratory	4	1	2	2	1	1	3	1
Hygiene	0	2	0	1	0	0	1	1
TOTAL:	292	327	328	310	347	374	313	312

Fig. 8.11 Recruiting Requirements by Category and Year for the Year Preceding 1 January

Recruiting Limits for the Year Preceding:								
Category/1Jan:	83	84	85	86	87	88	89	90
Pilot	75	75	75	75	75	75	75	75
Navigator	30	30	30	30	30	30	23	30
Aeronautical	20	20	30	30	30	35	40	40
Radio	25	25	35	35	35	40	45	45
Armament	7	8	10	10	10	10	10	10
Instrument	8	8	13	13	18	18	18	18
Electrical	8	8	8	8	8	8	8	8
Equipment	55	60	60	65	65	65	65	65
Works	5	6	7	7	7	7	7	7
Administrative	45	45	45	45	45	45	45	45
Air Traffic	35	35	35	35	35	35	35	35
Air Defence	8	9	9	9	9	9	9	9
Intelligence	9	9	9	9	9	9	9	9
Education	20	20	20	20	20	20	20	20
Ground Defence	5	5	5	5	5	5	5	5
Photographic	5	5	5	5	5	5	5	5
Police	5	5	5	5	5	5	5	5
Legal	5	5	5	5	5	5	5	5
Doctor	10	10	10	10	10	10	10	10
Dentist	15	15	15	15	15	15	15	15
Nurse	30	30	30	30	30	30	30	30
Pharmaceutical	5	6	5	5	5	5	5	5
Radiographer	5	6	5	5	5	5	5	5
Laboratory	7	8	8	8	8	8	8	8
Hygiene	4	8	4	4	4	4	4	4

Fig. 8.12 Recruiting Limits by Category and Year
for the Year Preceding 1 January

Firstly, examine the recruiting rate for the Pilot Category. Note that the number of recruits for 1984 (1 January 1985 column) drops to about half of the 1982 (1 January 1983 column). The reason for this decline can be seen by referring to the strength versus years of service Figures 8.9 and 8.10. As the strength wave caused by the Vietnam conflict enters the low wastage 15 to 20 years of service zone, wastage of pilots drops, resulting in a reduced recruiting requirement. As some of the group reach 20 years of service, and thus a high wastage rate zone, the wastage rate rises. This effect is most marked in the Pilot Category. There is a different effect in the Engineer Branch (Categories Aeronautical to Electrical). During the Vietnam conflict, a shortage of engineers led to commissioning a significant number of noncommissioned officers (sergeants and flight sergeants) who already had about 10 years of service. This group of officers reached 20 years of service several years ago, and the consequent high wastage rate from the Engineer Branch has produced a number of problems in maintaining the strength of this Branch, as the action to recruit replacements, required four to five years in advance of the higher wastage rate, was not taken. This situation could be confirmed by using the Tabulate option to print the years of service of the Engineering Branch and comparing it to the rest of the Air Force. Figure 8.13 shows this plot for the year 1982.

ROYAL AUSTRALIAN AIR FORCE OFFICER CORPS

Strength versus Years of Service as at 1 January 1982

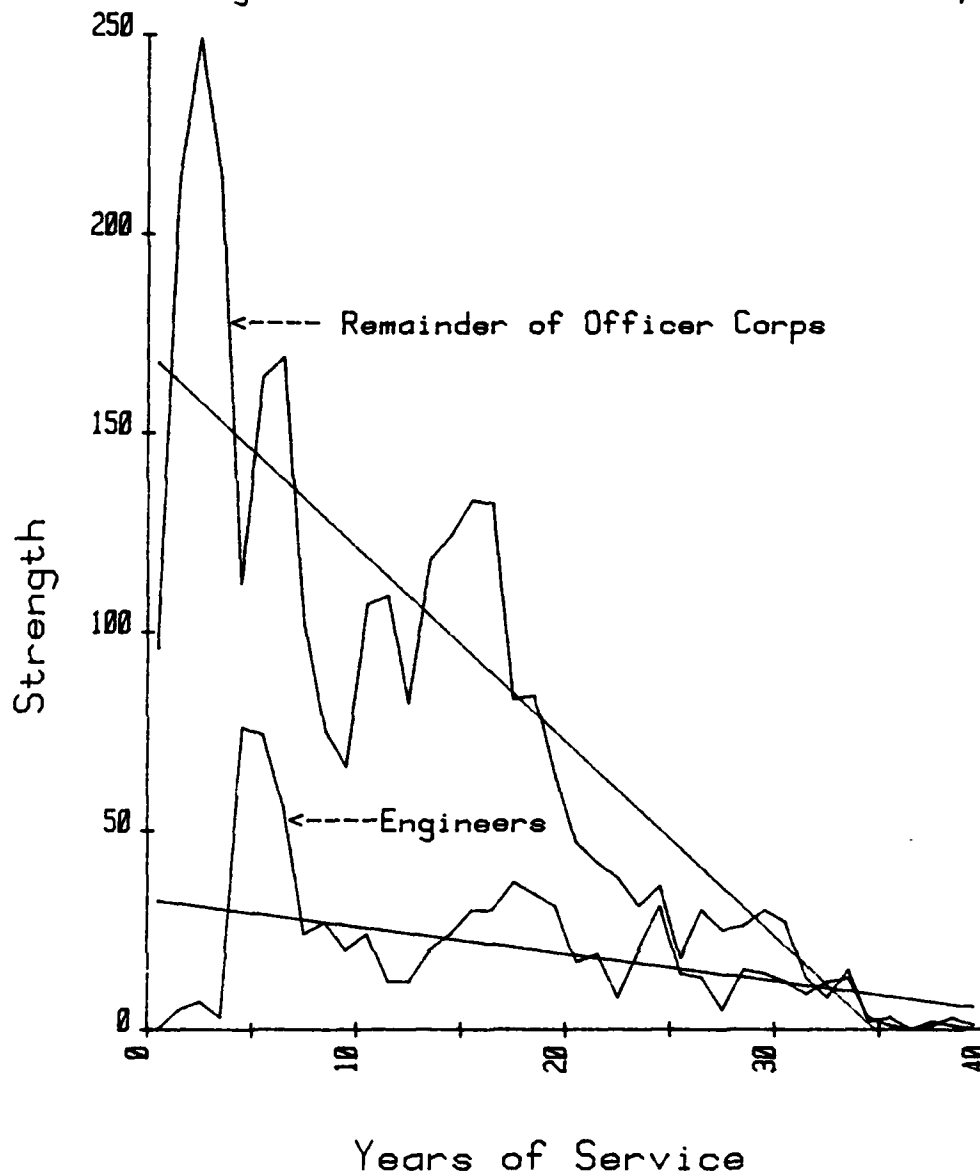


Fig. 8.13 Strength versus Years of Service as at 1 January 1982

The chronic shortfall in strength in the Engineer Branch that resulted can be seen in the recruiting figures as a high demand rate that is at the limits of the ability to provide recruits. One of the main purposes of the ROS model is to prevent recurrences of such situations.

Secondly, make a comparison of the values in the two figures 8.11 and 8.12. Figure 8.11 contains recruiting figures produced from one run of the ROS model, while Figure 8.12 contains the recruiting limits, which are an estimation of the maximum number of recruits that can be introduced as a result of factors such as training limits and limits to the number of volunteers for a Category. If the model requests more than the recruiting limit, the number of officers introduced into the simulation as recruits will be constrained to the recruiting limit. Thus, if the number of recruits is at the recruiting limit, this is an indication that the strength management is either "out of control" or at the limits of control. Subsequent printout of the Establishment/Target/Actual/Balance (ETAB) table will show the shortage. Note that several Categories are in this situation (e.g., Navigator, Aeronautical, Radio, Armament, and Doctor). Strength shortfalls can be expected in these categories. Reference to Figure 8.8, the predicted category strength shortfall, shows this situation to be the case. By increasing the recruiting limits, reducing Category wastage, or reducing

growth, if possible, the situation can be brought under control. Ideally, there should be some reserve capacity in the recruiting and training system to allow for fluctuation in the wastage and growth rate. If this reserve capacity can be provided, the strength management problem becomes much simpler, as slightly higher demands for recruiting than expected can be absorbed by the reserve capacity. One of the unfortunate factors in strength management is that if a strength shortfall occurs for any reason, it will be carried forward to the next year, providing additional load on the recruiting and training system. Thus, while strength surpluses can be handled easily (e.g., by reducing or stopping recruiting for a time), recovery from a strength shortfall is much more difficult. Assuming that expected values have been given to the model as suggested, cases where the Category strength will go "out of control" as shown by demands for recruits at the limit of the recruiting rate should be examined very carefully, and if additional capacity cannot be found, the strength of the Category should be carefully monitored to allow early action to be taken before the problem becomes chronic. Clearly, using the ROS model to predict such situations is an efficient and effective way of providing such monitoring.

Model Variability

In Chapter 7, the issue of model variability was discussed. Given the stochastic nature of events such as wastage and promotion, some variation between runs must be expected. An experiment was conducted to evaluate the variability of the model, and the number of officers eligible for promotion in the General Duties Branch was chosen as the parameter to evaluate. The model was advanced from the base year, and when 1983 was reached, the Tabulate option was used to extract the number of General Duties officers eligible for promotion from the data base. When this report had been obtained, the restart option was invoked. This option reloads all the data base files but does not reset the random number generator, so that on the next run, the model starts with a new random number stream and thus gives a different set of results. This process was carried out a number of times in order to yield the five sets of results shown in Figure 8.14. Five runs were completed as this number seems to be a good compromise between estimating the standard deviation of the variability and the time taken to run the model, which can be extensive for complex experiments.

As can be seen from Figure 8.14, some variability is evident. By examining the standard deviation of the results, the operator can obtain an estimate of the range

Predicted Number of Officers Eligible for Promotion in the General Duties Branch, at 1 January 1983						
Category/Rank:	1	2	3	4	5	6
Run 1	101	173	106	86	32	8
Run 2	105	169	103	76	30	6
Run 3	102	169	105	84	33	8
Run 4	102	181	115	92	34	8
Run 5	100	177	107	85	29	8
Mean	102	174	107	85	32	8
Standard Devn	1.9	5.2	4.6	5.7	2.1	0.9

Ranks: 1 = Flying Officer
2 = Flight Lieutenant
3 = Squadron Leader
4 = Wing Commander
5 = Group Captain
6 = Air Commodore

Fig. 8.14 Officers Eligible for Promotion: as at
1 January 1983 for the General
Duties Branch

of values the "real world" can take about the expected value. The implicit assumption in the previous statement is that the model has been validated by the method(s) suggested in Chapter 7 and that it has been provided with data that is the best estimate of future events, as suggested above. Estimation of the number of officers eligible for promotion is a common Personnel Division task; thus the variability of the results is directly relevant to a possible use of the Model. In the case of the number of General Duties officers eligible for promotion, the variability of results as estimated by the standard deviation is generally much less than 10 percent of the mean. The opinion and experience of the author (Mills, 1979-1981) is that such a range of values is small enough to be sufficiently accurate for management purposes, given the often subjective nature of personnel administration. The conclusion is that the model estimates could be directly used for promotion board deliberations. Estimation of eligibility and promotion vacancies is a time-consuming business, taking several man-days for each promotion board. The ROS model can provide the necessary advice with about two man-hours' effort. Thus, one of the potential uses of the ROS is its ability to complete routine personnel administration tasks with a greatly reduced expenditure of human effort.

Royal Australian Officer Corps Costs

This example of a possible use of the model has been left until last, as it is the latest module to be added to the model. Two types of costs are represented: salary and training. Note that these costs are subject to variation due to the stochastic nature of the model, and thus the costs presented here are an example extracted from a single run of the model. If the expected costs are required, then several runs of the model should be made using the "restart" option, and the resulting cost figures averaged to produce an estimate. The run chosen to give representative figures is the final "run six" as used above. Figures 8.15, 8.16, and 8.17 provide a summary of the results for salary, training, and total costs respectively. In these figures, costs have been expressed as \$Australian * 1,000,000, listed to three significant figures to allow all the costs to be included on a single page. In the model, invoking the "C" for "Costs" option produces a table where costs are expressed as integers to single dollar precision. Since this format produces a lengthy printout, a compressed format was chosen to present the results. Another factor in the presentation of costs is the exclusion of factors for inflation or discounting to present values, discussed in Chapter 6. Ignoring these factors allows direct comparison of the effect of policy

Officer Corps Salary Costs for the Year Preceding:								
Class/1 Jan	83	84	85	85	87	88	89	90
CATEGORY:								
Pilot	27.1	26.1	26.5	26.3	26.7	26.9	26.8	26.5
Navigator	11.6	11.7	11.9	12.2	12.5	12.4	12.2	12.4
Aeronautical	8.41	8.53	8.73	8.71	8.73	8.94	8.75	8.73
Radio	8.03	8.23	8.54	8.65	8.65	8.63	8.75	9.10
Armament	1.99	2.04	2.21	2.18	2.16	2.21	2.28	2.34
Instrument	2.37	2.48	2.50	2.50	2.60	2.59	2.71	2.58
Electrical	1.47	1.56	1.60	1.50	1.55	1.58	1.56	1.55
Equipment	14.6	15.1	15.6	15.8	16.1	16.5	16.6	16.7
Works	0.88	0.95	0.97	1.02	1.05	1.09	1.10	1.14
Administrative	9.69	9.90	9.94	10.2	10.3	10.7	10.3	10.2
Air Traffic	6.91	7.15	7.54	7.76	8.00	8.06	8.21	8.16
Air Defence	1.74	1.84	1.81	1.85	1.95	2.06	2.11	2.05
Intelligence	1.51	1.55	1.71	1.80	1.89	1.94	1.95	1.90
Education	3.48	3.77	3.82	3.91	4.16	4.15	4.24	4.05
Ground Defence	1.06	1.06	1.11	1.16	1.18	1.15	1.20	1.22
Photographic	0.39	0.39	0.44	0.45	0.43	0.48	0.47	0.48
Police	0.71	0.69	0.63	0.65	0.70	0.63	0.65	0.63
Legal	0.35	0.38	0.35	0.35	0.33	0.36	0.34	0.41
Doctor	2.16	2.21	2.46	2.57	2.56	2.47	2.25	2.31
Dentist	1.53	1.58	1.53	1.60	1.72	1.75	1.83	1.71
Nurse	2.76	2.97	3.06	3.17	3.03	3.21	3.12	3.15
Pharmaceutical	0.36	0.35	0.34	0.36	0.39	0.39	0.40	0.38
Radiographer	0.15	0.18	0.18	0.16	0.17	0.21	0.19	0.17
Laboratory	0.26	0.22	0.22	0.23	0.26	0.22	0.23	0.24
Hygiene	0.16	0.21	0.17	0.17	0.21	0.17	0.18	0.18
BRANCH:								
General Duties	38.7	38.6	38.4	38.5	39.2	39.3	39.1	38.8
Engineer	22.3	22.8	23.6	23.5	23.7	24.0	24.1	24.3
Equipment	15.9	16.0	16.6	16.8	17.2	17.6	17.3	17.8
Special Duties	25.8	26.7	27.4	28.2	29.0	29.5	29.5	29.1
Medical	7.40	7.71	8.00	8.27	8.34	8.43	8.19	8.13
RAAF TOTAL:	110	112	114	115	117	119	118	118

Fig. 8.15 Salary Costs by Category, Branch, and RAAF for the Year Preceding 1 January for "Run Six" of the ROS Model

Note: Costs are in \$Australian * 1,000,000.

Officer Corps Training Costs for the Year Preceding:								
Class/1 Jan	83	84	85	86	87	88	89	90
CATEGORY:								
Pilot	8.40	6.44	4.20	4.20	6.72	8.12	8.96	8.68
Navigator	2.55	2.55	2.55	2.30	2.21	2.30	1.53	1.87
Aeronautical	1.00	1.00	1.40	1.30	1.50	1.75	1.25	1.15
Radio	1.25	1.25	1.75	1.75	1.75	1.70	1.30	2.00
Armament	0.32	0.32	0.45	1.36	0.27	0.27	0.27	0.45
Instrument	0.16	0.32	0.36	0.32	0.44	0.40	0.56	0.32
Electrical	0.84	0.21	0.34	0.21	0.25	0.25	0.13	0.13
Equipment	2.70	0.29	0.32	0.30	0.29	0.28	0.22	0.22
Works	1.25	0.15	0.03	0.05	0.03	0.05	0.05	0.08
Administrative	1.32	0.24	0.14	0.19	0.23	0.28	0.19	0.14
Air Traffic	4.25	0.58	0.70	0.73	0.80	0.68	0.65	0.58
Air Defence	5.20	0.59	0.33	0.26	0.46	0.59	0.59	0.59
Intelligence	0.63	0.06	0.06	0.06	0.05	0.06	0.05	0.03
Education	0.48	0.24	0.14	0.08	0.19	0.17	0.18	0.08
Ground Defence	0.90	0.05	0.07	0.09	0.09	0.09	0.09	0.09
Photographic	0.14	0.01	0.01	0.01	0.00	0.01	0.01	0.01
Police	0.33	0.03	0.01	0.01	0.03	0.01	0.01	0.00
Legal	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.02
Doctor	0.54	0.60	0.60	0.54	0.30	0.24	0.00	0.36
Dentist	0.19	0.24	0.10	0.14	0.29	0.29	0.43	0.19
Nurse	0.01	0.07	0.08	0.11	0.06	0.09	0.05	0.05
Pharmaceutical	0.05	0.03	0.00	0.03	0.05	0.05	0.08	0.05
Radiographer	0.02	0.04	0.02	0.00	0.00	0.04	0.02	0.00
Laboratory	0.03	0.01	0.01	0.01	0.02	0.00	0.00	0.00
Hygiene	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
BRANCH:								
General Duties	11.0	9.00	6.75	6.50	8.93	10.4	10.5	10.6
Engineer	2.81	3.10	4.30	3.94	4.21	4.37	3.51	4.05
Equipment	0.40	0.44	0.35	0.35	0.32	0.33	0.27	0.30
Special Duties	1.32	1.81	1.48	1.44	1.85	1.88	1.75	1.53
Medical	0.85	1.00	0.81	0.82	0.73	0.71	0.58	0.66
RAAF TOTAL:	16.3	15.3	13.7	13.0	16.0	17.7	16.6	17.1

Fig. 8.16 Training Costs by Category, Branch, and RAAF for the Year Preceding 1 January for "Run Six" of the ROS Model

Note: Costs are \$Australian * 1,000,000.

Officer Corps Total Costs for the Year Preceding:								
Class/1 Jan	83	84	85	86	87	88	89	90
CATEGORY:								
Pilot	35.5	33.4	30.7	30.5	33.5	35.0	35.8	35.1
Navigator	14.1	14.3	14.4	14.5	14.7	14.7	13.8	14.2
Aeronautical	9.42	9.54	10.1	10.0	10.2	10.7	10.0	9.88
Radio	9.28	9.48	10.3	10.4	10.4	10.3	10.1	11.1
Armament	2.31	2.35	2.66	2.54	2.43	2.48	2.55	2.79
Instrument	2.54	2.80	2.86	2.82	3.04	2.99	3.27	2.90
Electrical	1.56	1.77	1.93	1.71	1.80	1.83	1.68	1.68
Equipment	14.9	15.4	15.9	16.1	16.4	16.7	16.8	16.9
Works	1.01	1.10	1.00	1.07	1.07	1.14	1.15	1.21
Administrative	9.83	10.1	10.1	10.4	10.6	11.0	10.5	10.4
Air Traffic	7.33	7.73	8.24	8.48	8.80	8.74	8.86	8.74
Air Defence	2.26	2.42	2.14	2.11	2.41	2.64	2.69	2.63
Intelligence	1.57	1.62	1.77	1.86	1.94	2.00	2.00	1.93
Education	3.53	4.01	3.97	4.00	4.35	4.32	4.42	4.14
Ground Defence	1.15	1.11	1.18	1.25	1.27	1.24	1.29	1.31
Photographic	0.40	0.40	0.45	0.46	0.43	0.50	0.47	0.48
Police	0.74	0.72	0.64	0.67	0.72	0.64	0.66	0.63
Legal	0.35	0.39	0.36	0.36	0.33	0.37	0.34	0.43
Doctor	2.70	2.81	3.06	3.11	2.86	2.71	2.25	2.67
Dentist	1.72	1.82	1.62	1.75	2.01	2.04	2.26	1.90
Nurse	2.78	3.04	3.14	3.28	3.09	3.29	3.16	3.20
Pharmaceutical	0.42	0.38	0.34	0.39	0.45	0.44	0.48	0.44
Radiographer	0.17	0.22	0.20	0.16	0.16	0.25	0.21	0.17
Laboratory	0.29	0.22	0.23	0.24	0.27	0.22	0.23	0.24
Hygiene	0.16	0.22	0.17	0.17	0.23	0.17	0.18	0.18
BRANCH:								
General Duties	49.7	47.6	45.1	45.0	48.2	49.7	49.5	49.4
Engineer	25.1	25.9	27.9	27.5	27.9	28.3	27.6	28.3
Equipment	15.9	16.5	16.9	17.2	17.5	17.9	18.0	18.1
Special Duties	27.2	28.5	28.8	29.6	30.8	31.4	31.2	30.7
Medical	8.25	8.71	8.76	9.10	9.07	9.14	8.77	8.79
RAAF TOTAL:	126	127	128	128	133	136	135	135

Fig. 8.17 Total Costs by Category, Branch, and RAAF for the Year Preceding 1 January for "Run Six" of the ROS Model

Note: Costs are in \$Australian * 1,000,000

changes on costs. Both inflation and discounting are proportional to the base rate; hence, their inclusion would only make such comparisons difficult without adding to the information content of the model.

Salary Costs. The salary costs for a section of the Officer Corps (e.g., a Category or Branch) depends on three factors--the level of salary, the number in the section, and the structure of the section. In the scenario, salaries are fixed; however, growth is attained which increases costs, but as younger, lower ranked officers replace the older, higher ranked officers (assuming not all promotion vacancies can be filled), salary costs for the entire force decrease. The net effect of these two forces can be seen in the total: salary costs rise steadily until 1988, then decrease slightly. One conclusion is that initially growth is the prime factor in costs; however, as the target is reached and the structure of the Officer Corps changes, costs reduce slightly. Examination of individual Category figures show different net effects depending on the state of the Category. For example, in the case of the Pilot Category, within the limits of model variability, costs are essentially constant, since strength and structure is held fairly constant. In the case of the Equipment Category, where steady growth is allowed, costs rise steadily. These examples show that the salary

cost calculations presented by the cost option are useful to gauge the aggregate effect of factors that affect salary.

Training Costs. The factors that affect training costs are the cost of acquiring/training an officer, growth, recruiting limits, and wastage levels, since each officer who leaves must be replaced. Figure 8.16 estimates the training costs by determining the number of officers recruited during the period of interest. The effects of the Vietnam conflict on wastage levels was noted above, and can be seen again in the total wastage figures. As officers enter the 15 to 20 years of service low wastage rate zone, wastage and hence training costs initially decrease, then increase as some of these officers attain 20 years of service and enter the high wastage rate zone. This effect is particularly noticeable in the Pilot Category. Other trends in training costs can be seen and again depend on the aggregate of forces acting on the Category. For example, in the Navigator Category, training costs are initially constant as a constant number are trained to fill a strength shortfall, then ease as the Category strength comes under control. Similar effects can be seen in other Categories.

Total Costs. Figure 8.17 shows the aggregate costs. These show a growth to 1988, then a slight

decline, which is the expected result, since total costs are simply a sum of salary and training costs.

Conclusions. As stated in Chapter 6, the cost module is largely experimental and, unlike other sections of the model, has not yet been put to any "real" use. However, the results obtained show that at least as a starting point, reducing the structure to a cost figure is possible. More work will probably need to be done to align cost figures with those determined in the "real world;" however, this is likely to require data rather than extensive programming changes. Thus, the costing module added should provide a useful starting point for such work.

Conclusions

This chapter has described a number of uses for the ROS model. Although these are representative, they by no means provide a complete picture of the kinds of experiments for which the model can be used. The variety of research questions that arise in personnel administration is very high, mainly because of the large number of states that may be produced by the "effector" variables that affect the structure of the organization. The purpose of constructing a nearly isomorphic model of the Royal Australian Air Force Officer Corps is to provide a

tool that can be used to examine the effects of changes in these "effectors" on the structure of the Officer Corps.

Three factors assist such research. Firstly, the operator can make changes to the model's data base by editing the input data files or by changing interactive operator responses from the terminal as the simulation proceeds. Secondly, the consequent structure of the Officer Corps, as represented by the simulation, can be readily determined using either the fixed format reports such as the ETAB table or the variable format tables provided by the Tabulate function. Finally, and most importantly, the model processes each officer in the same (isomorphic) way as does the Royal Australian Air Force Personnel Division; thus, the "real world" response to a change in factors that affect the Officer Corps structure can be accurately simulated using the ROS model.

Chapter 9

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

In this final chapter of this thesis, three sections are included. A brief summary provides an overview of the work done. Conclusions comment on the results of the work. Recommendations point to future work that could be done in the area. Combined, the three sections provide an "executive summary" of the thesis.

Summary

Chapter 1: Background. The first chapter reaches a statement of the problem to be researched, by placing the subject in context with the rest of the world. The Royal Australian Air Force (RAAF), in common with other Armed Services in the world, seeks to make optimum use of the resources made available to it. One of these resources is manpower. The high cost of training, salaries, the long lead time required to obtain skilled personnel, and the number of factors which affect the structure of the Service make it essential to manage the manpower resource in a skillful manner. The essence of the problem is to "manage the manpower resource in a way that maximizes the effectiveness and efficiency of the Armed Services."

Chapter 2: Functions of a Personnel System. The management of manpower is presented as a purposeful, systematic activity. Strategic assessments lead to a demand for a defense capability, and to meet this requirement, tasks and resources are allocated. The tasks are factored in a way that yields (amongst other things) an organization, and authority to fill that organization with personnel, although at times there is a shortfall in the allocation of resources compared with the number of personnel assessed as being required to complete the tasks. Resource allocation rules for the RAAF under such circumstances are identified. Next, a sequence of activities in the Personnel Division is defined. The initial activity, and the one that has greatest effect on the structure of the Service, is loss of personnel (for any reason), defined as "wastage." Promotions take place annually to replace wastage and allow growth, where necessary. At the lowest level of the structure, recruitment and training accommodates the net effect of growth and wastage. Some of the complexities of these activities are identified, and the "systems" method management of these activities is recommended, because of the complexity of the situation. A "systems" approach is one that considers the whole of the problem simultaneously, rather than more usual "analytical" methods where segments of the problem are attacked piecemeal.

Chapter 3: Literature Review. The purpose of this chapter is to place the thesis work in context with similar work being done elsewhere. Two thrusts were pursued--military and civilian. The military work was identified largely through the Defense Logistics Studies Information Exchange (DLSIE). This search revealed a very high level of activity, with well over 100 computer simulation models being listed. Of the U.S. Armed Services, the U.S. Navy seems to be the most active, and two models very similar to the work reported in this thesis were listed. The U.S. Air Force also has at least one model of a similar type to the RAAF Officer Structure (ROS) model. In complete contrast, very little work of a similar nature could be found in the civilian literature. There were a number of articles that identified the issues in human/manpower resource management, but only one showed evidence of implementation of the principles in a working organization. Comments within the articles showed that the authors had also found little evidence of computer-assisted manpower management. Speculation on the reason for this disparity concludes that a transfer of computer simulation technology from the weapons development area to the resource management area is the most likely cause for the substantial lead the military has over civilian organizations in this method of manpower resource management.

Chapter 4: Computer Assisted Strength Management.

The rationale for computer-assisted strength management is outlined; the large number of factors involved and the number of calculations required places the problem beyond manual endeavor, at least using a reasonable amount of resources for the development process. The concept of "isomorphic" models is introduced; an isomorphic model of an organization is one which treats the entities in the model in the same way as they are treated in the "real world." Two models, Force Variation (FORVAR) and ROS are described. FORVAR is a strategic planning model, which allows rapid assessments of the number of personnel required as a result of a change in strategic circumstances which affect force structure. ROS is a model which takes the output of the FORVAR model and develops a plan to achieve the changes identified by FORVAR. Thus, the two models form a planning hierarchy. The method of developing a plan is outlined. Iterative planning is recommended. In this method, closure on a feasible and acceptable plan is accomplished by using the models to identify infeasible changes, then cyclically amend the strategic plan using FORVAR, and then test the consequent changes with the ROS model until a satisfactory result is obtained. Since such work would be beyond the capacity of a manual planning system, the use of computer assistance

in this manner is considered essential. The final section of this chapter identifies the thesis task, repeated below.

Chapter 5: RAAF Officer Structure Model. The ROS model has a long history, being developed for the Australian Army and Navy by (what is now) the Central Studies Establishment, using modeling techniques derived from experience gained in weapons development. The need for a comprehensive model is identified. The model was constructed to be "isomorphic" (i.e., "of like or similar form"), with FORTRAN being chosen as the language, to allow the management of a large data base and the production of formatted reports. Running the model requires a mini-computer; the simulation program calls on four data files as inputs and uses a further four files as working or output files. The model, being isomorphic with the RAAF Personnel Division, processes activities in the same order as the Division. The demand for officers is read from a data file, the operator (interactively) designates the resources allocated, and the model distributes these resources via allocation rules. Next, wastage is determined, followed by promotion to meet the requirements set by wastage and growth. Recruits are introduced and, finally, the model reorganizes and ages all the officers in the Service (the model uses a time step of one year). Extensive output is available from the model, and these

documents may be printed at the terminal for the operator, or written onto a file for later printing by a high-speed printer. Some of the reports are identical to those used in the manual, short-term, strength management system, so that no training is required to teach people to interpret the results. Other reports allow the operator to construct reports on the structure of the service by any combination of time in rank, length of service, Category, Branch, significant change indicator, and eligibility for promotion. A new section of the model allows the estimation of salary and training costs.

Chapter 6: Assumptions, Approximations, and Future Development. The purpose of this section of the thesis is to provide the reader with an understanding of the assumptions and approximations used in the model, which should give a good understanding of the limitations of the model and, at the same time, point to improvements that can be made in the model (hence the insertion of this subject in the chapter, rather than at the end, as is more usual). A time step of a year is used, and the status of an officer is assessed at that time, even though many of the processes are continuous. The method of recording the "Establishment" or demand for officers is identical to the manual system, and the model assumes that the future Establishment will be known. Resource allocation is based on

arbitrary rules, but these also are the same ones used by Personnel Division. Wastage is modeled as a loss from each Branch of the Service, from each year of service, and the estimate of the loss rate is based on historical records. One of the problems encountered is the small wastage data base, and the suggestion is made to improve this section of the model. Representation of the promotion system is problematical, as the rules for promotion are not well defined in the Personnel Division; this section of the model is based on an observation of the behavior of promotion boards and is, of necessity, rather empirical. Analytical methods of improving this section of the model are suggested. Recruitment modeling follows the practices of personnel division, although only a single figure for years of service on appointment is included, whereas a range of values is actually the case. The new section of the model, costing, is largely experimental. The timing of costs is discussed, as are a number of errors in estimation of training and salary costs. No use of factors to allow for inflation has been made, as the use of "constant dollars" allows the cost consequences of policy changes to be directly assessed.

Chapter 7: Verification, Variability, and Validation. Validation of computer simulation models is often very difficult, as the very complexity that led to the

construction of the model often defeats attempts to complete validation. The focus of this chapter is a description of methods of verification and validation, rather than the completion of the process. The reason for this approach is lack of access to the necessary data and the time lapse needed to conduct a validation. Verification, the process of ensuring the model is processing data as intended, is attempted. Several methods of verification are suggested. The simplest is to use outputs from the model to establish that the model processes officer data as intended. More complete verification involves modification to the model's source code. Much of this type of work was completed in Australia, and the verification of this type was mostly confined to extensions and improvements in the model. Model variability is the tendency for the model to produce somewhat different results on different runs (when a different random number stream is used), due to the stochastic nature of the processes in the model. The suggestion is that if expected values are to be obtained, then the model should be run at least five times with the same input data, and the results averaged to obtain an estimate of the variable of interest. Validation is the process of building confidence that the model will produce forecasts of sufficient accuracy to be of use. Again, several methods of validation are suggested. The simplest, the "Turing" test, was conducted by the author.

More complex and analytical methods require collecting data from the "real world" and comparing the predictions of the model with the events in the world. This process takes at least one step of the model (i.e., at least one year) so work in this area had to be confined to a description of this validation strategy.

Chapter 8: Examples of the Use of the RAAF Officer Structure Model. This "results" chapter shows several uses of the model. Since the prime purpose of the model is to assist with strength management, most of the chapter is devoted to an experiment in this area. A scenario is described in which strength, establishment, and resource allocation will be "forced" to converge on 4000 by the year 1990 is used. An iterative approach to the problem is taken, and at the end of each run, new measures are introduced to reach the objective. After six runs, the objective is achieved, and the inputs to this final run are used to define an Officer Corps management policy to achieve the objective. The next experiment is an examination of the effect of peaks and valleys in the number of officers in each year of service, caused by high recruiting rates during (for example) the Vietnam conflict. Such an examination can explain many of the dynamic processes in the Officer Corps structure, and a three-dimensional plot of number per year of service versus years of service

versus years is included and shows very clearly the peaks and valleys that can lead to strength management problems. The distribution of strength versus years of service for the Engineer Branch and the rest of the Service is also plotted. The number of recruits required by the plan, as developed by the iterative process, is included to demonstrate the use of the reporting functions of the model to service other organizations (the recruiting organization in this case). Since the model requires data from many sources, it should also return planning information to those who supply model inputs. Model variability is estimated by printing the number of General Duties Branch officers eligible for promotion on 1 January 1983, for five runs of the model. The conclusion was that model variability was much less than 10 percent between runs, which is a very useful result. Finally, examples of the new cost module are given, with tables of salary, training, and total costs being provided. Some explanation for trends in this data is given.

Annex A: Implementation and Operation of the RAAF Officer Structure Model. This annex was included as technical documentation to assist the introduction of the model to a new site. In the two chapters, methods of loading the model and a set of demonstration data files, and the methods of updating those files with current data

are given. Because of the technical nature of this section, a further description of Annex A will not be given.

Conclusions

In this section of the chapter, conclusions will be drawn. Essentially, the process is a comparison of the thesis task with the outcome of the thesis work. For a complete description of the thesis task, as described in Chapter 4, see either that chapter or the description reproduced here. The task, as outlined there, was to:

1. convert the present ROS code to ANSI standard FORTRAN 77 to enhance its portability between computers;
2. provide a capability to produce tables which detail the cost of salaries and training;
3. make minor changes to the code to enhance the usefulness of the model;
4. show the internal validation of the model, and suggest methods for completing external validation; and
5. document the model, including an operations manual which will assist the transfer of the model to a new computer and the subsequent maintenance of the model as a planning tool.

Code Conversion. No detailed description of the code conversion process has been described here, as the

process was essentially the process of implementing the model on the Harris mini-computer, which has a FORTRAN 77 compiler. During the process of conversion (and extension), both the Harris mini-computer and a Cyber 175 were used. The Harris FORTRAN 77 compiler was, by comparison with the Cyber, more "fussy" about exact compliance with the American National Standards Institute (ANSI) specifications. Thus, the use of the Harris compiler explicitly ensured compliance with the ANSI standard. Considerable work was involved in the conversion process, although little has been said about the work done, as it was primarily (complex) editing.

Costing Capability. The costing capability was introduced into the model, and the results of this work have been discussed in some detail. The assumptions made are detailed in Chapter 6 and the verification and validation methods in Chapter 7. Although the facility met the specifications of the author, the cost tables have yet to be put to a "real world" use, and the usefulness of this section of the model has yet to be demonstrated. However, the code necessary to extract the data from the Officer Corps data base, during the running of the model, is now in place, and modification to meet user's requirements should only involve relatively minor changes to the code.

Enhancements. Many enhancements were made to the model, to make the model easier to run, and allow the operator more dynamic control over the progress of a simulation. Examples are the introduction of a wastage factor for each year of the simulation, the ability to "spool" model output to a high speed printer (which can reduce the time taken for a simulation run by a factor of 5), and the use of a separate recruiting limit for each year of the simulation. No doubt other minor modifications will be made in the future in order to keep the model processing methods in line with those used manually in the Personnel Division; however, in its present form, the model is very "useable."

Internal and External Validation. Internal validation or verification has been completed to the satisfaction of the author, and the method used is described in Chapter 7. External validation, called simply "validation" in Chapter 7, could not be achieved for the reason given above; however, detailed comments on the method of validation were given, which was the thesis task.

Model Documentation. This thesis documentation provides a detailed documentation of the ROS model.

Additional Work. In addition to the work originally called for, a whole chapter of the thesis

(Chapter 6), was devoted to the subject of assumptions and approximations used by the model. This area of documentation is valuable in providing the means for potential users to understand the limitations of the model. In addition, Annex A was completed to provide a description of the way the model can be implemented and operated on another computer.

In summary, the work originally contracted for at the start of work on the thesis was completed, with some extension beyond the original tasks. The process of conversion and verification suggests that the model is now ready for implementation in the RAAF Personnel Division. Accordingly, the most general conclusion is that the RAAF Officer Structure Model is now ready for operational use, subject to validation.

Recommendations

The primary recommendation is that the model be implemented on the new RAAF Personnel Division mini-computer, and that at the same time, the validation process detailed in Chapter 7 of this report be started. Assuming validity is demonstrated, the model should then be used to develop long-range plans for the strength management of the RAAF Officer Corps.

Secondary recommendations concern development of the model. Before making changes to the model, the

analyst should ensure that the changes will have a benefit of improved predictive accuracy greater than the cost of development. A number of areas of the model could be developed; only the main areas will be identified. In general, comment will be made on those changes that will require reprogramming sections of the model. Many areas of the model could be improved through manipulation of the input data, and this work should be part of the implementation/validation work.

Wastage Representation. Loss of officers from the Officer Corps is (generally) the most significant variable in defining the structure of the Corps. At present, wastage representation is done by Branch and years of service. This may not be the most accurate method. Improved wastage representation should be investigated, as described in Chapter 6.

Promotion. The representation of promotion is largely based on empirical observation, and the probability of promotion for the ranks of Flight Lieutenant, Squadron Leader, and Wing Commander should be improved through analytical examination of promotion results. The promotion algorithm itself should also be critically examined.

Years of Service on Recruitment. If the model is to be used for projections beyond about 5 years, the present

method of providing a mean number of years of service to each recruit may not be sufficiently accurate. An alternative method would be to determine the distribution of years of service for each Branch or Category and select the years of service from this distribution. The price that must be paid here is greater variability in the results from the model, which could, in some cases, require additional runs to estimate variables with sufficient accuracy.

Costing. The costing module should be subject to some practical use. If "budgeting" level accuracy is required, some changes will probably be required. However, if the relative cost of changes of policy is all that is required, the present program will probably suffice.

Resource Allocation. The present method of allocating the Authorized Terminal Strength to the Establishment depends on a reasonable fixed percentage shortfall between the two figures. If, after several years of use, the present percentage changes, the allocation algorithm should be amended. The parameters for the allocation are "hard wired" into the code and are relatively easy to change, so such changes could come under the heading of "model maintenance."

In conclusion, the RAAF Officer Structure Model has been developed over several years, and the users have

worked closely with the programmers, so many of the development iterations have already taken place. The suggestions made above are essentially "fine tuning" a decision support tool now ready for full operational use.

ANNEX A

**IMPLEMENTATION AND OPERATION OF THE
RAAF OFFICER STRUCTURE MODEL**

Annex A

IMPLEMENTATION AND OPERATION OF THE RAAF OFFICER STRUCTURE MODEL

Introduction

This annex discusses the implementation and operation of the Royal Australian Air Force (RAAF) Officer Structure (ROS) Model. The discussion in this annex is supported by a number of documents included as appendices at the end of this annex; these appendices include listings of the ROS program, data files, and job streams. The examples of implementation will be from a Harris mini-computer system, as this was the machine used for this thesis. However, the experience of the author in using a number of mini-computers is that the methods of operation are quite similar; thus, examples given for the Harris computer are likely to be readily adapted to other mini-computer systems, provided the necessary syntax changes are made. An assumption made here is that the personnel responsible for installing the model will be reasonably familiar with their own computer and have a general understanding of the "normal" methods used in the computer industry to achieve the desired objective, e.g., creating, loading, and compiling a file. Thus, the objective of this

section of the thesis is to outline the principles involved in installation and operation, rather than machine specific instructions.

Annex A--Chapter 1

IMPLEMENTATION

Transfer Media

The Royal Australian Air Force (RAAF) Officer Structure (ROS) Model consists of a program file and four data files: systems, establishment, manpower, and costs. Using program DUMP and the job stream/macro DUMPRUN, listed at Appendices A and B respectively, these files were transferred to magnetic tape from the Harris computer. Note that the tape contains three copies of each file (in case one or more becomes corrupted) and that the files have been read line by line into a 135-character buffer from the Harris disk, then written to the tape. Thus, each file consists of a series of 135 character lines. Between each file, "*EOR" (for "end of record") has been written onto the tape to allow the files to be separated. The ASCII (American Standard Code for Information Interchange) code has been (implicitly) used in the transfer from disk to tape. Finally, the data has been written onto the tape in a nine-track, 800 bits per inch format. These standards are the ones most commonly used in the computer industry; thus, obtaining access to the data on the tape should in most cases present no problems.

Loading the Tape

At Appendix C, a copy of the LOAD program is included. This program is the "sister" of the dump program included at Appendix A. The first step is to type this program into the host computer and compile the program. The ROS and LOAD programs are written in standard ANSI (American National Standards Institute) FORTRAN 77, so this compiler will, of course, have to be used if additional translation work is to be avoided. When the compilation is successful and object code has been produced from the LOAD source code, it should be saved as a file. In the testing of the program, the author called it "LOADOBJ." For example, using the "GE" (equals "generate" command) and a job stream command to compile the program, the sequence is:

Command:	Effect:
GE,LOADSRC	Create a file for the LOAD program
GE,LOADOBJ	Reserve a file for the LOAD objective code
GE,LOADRUN	Reserve a file for the LOAD job stream. Type in the LOAD program using the computer's editor and save the text on the file "LOADSRC."

FTN77,LOADSRC Compile the LOAD program--an object file called "XE" is created by the Harris computer on successful compilation.

CO,XE,LOADOBJ Copy the object code to the LOADOBJ file.

The next step is to generate the new disk files which will accept the data from the tape. A suggestion is to call them by the same names as in the Harris version of the model, as then the thesis documentation will comply with the physical computer model. The files should be created in the order given below, as this will ensure that each file contains the correct data set. Creating files on the Harris computer is very simple: the "GE" command is used thus:

Command:	File Generated:
GE,ROSSRC	ROS Model Source Code
GE,SYSDATA	Systems Data
GE,ESTABDAT	Establishment Data
GE,RAAFMEN	Manpower Data
GE,COSTDATA	Cost Data
GE,ROSOBJ	Space for the compiled program
GE,RUNROS	Space for the ROS model job stream

When the load program is or has been compiled and saved and all the necessary files created, the next task is to create a "macro" or "job stream" to run the LOADOBJ program.

A word of explanation is in order here. FORTRAN uses numerical logical file numbers in the program, and before running a FORTRAN program, it is necessary to "tell" the computer the names of the files on the disk that comply with the logical file numbers in the program. This may be done interactively (i.e., via a terminal) in most cases; however, the process is tedious, especially if repeated, and the creation of a "job stream" (sometimes called a "job control language" (JCL)) file is recommended, as fewer errors, and greater convenience result. In addition to connecting files to the program, the job stream also connects physical devices such as printers, terminals, and tape drives to the program. An example job stream (called a "macro" on the Harris computer), included at Appendix D, is also listed below. The term "AS" means "assign."

Line:	Purpose:
MS	The macro starts
AS 6 = *	Connect the printed output from the program to the terminal
AS 30 = ROSSRC	Assign FORTRAN logical file 30 to the disk file ROS Source
AS 40 = SYSDATA	Assign FORTRAN logical file 40 to the file Systems Data
AS 50 = ESTABDAT	Assign FORTRAN logical file 50 to the disk file Establishment Data

AS 60 = RAAFMEN Assign FORTRAN logical file 60
 to the disk file RAAF Manpower

AS 70 = COSTDATA Assign FORTRAN logical file 70
 to the disk file Cost Data

AS 80 = :10 Assign FORTRAN logical file 80
 to the physical device 10 which
 on Harris computer is the tape
 drive

LOADOBJ Execute the program LOADOBJ

ME The macro ends

When the job stream macro "LOADRUN" has been created and saved, the tape can be mounted and the contents read into disk files. On the Harris computer, the command:

"REQ,Logical file number for the drive,Tape
 number,File Number"

is used to request a tape, as the computer will not accept tapes that are not in its library. Note that the job stream explicitly connects the physical device number to the program logical file number 80; this is not absolutely necessary as the "REQ" (equals "Request") command also connects the tape to the logical file 80. However, the line was included in the macro for the sake of completeness. After the tape has been mounted, the read process is initiated on the Harris computer by simply typing "LOADRUN." This command executes the LOADRUN job stream/

macro which, in turn, makes all the necessary assignment connections, then invokes the FORTRAN object code "LOADOBJ." This program now takes control. It rewinds the tape and all the files, reads 135 characters from the tape, and writes it to the disk file. When the character set "*EOR" is encountered, the program changes files, thus writing the data from the tape into the correct disk file. The program also advises the operator when reading into a file starts. If all goes well, at the end of the program, the ROS source text and its four data files will be on the disk files named above. The presence of the correct data can be confirmed by cataloging the files, examining the files with the editor, or dumping the files to a printer.

Compilation of the ROS Source Code

An object program must be made of the ROS model source code. There may be some changes to the source code required at this stage, as the program uses calls a random number generator, and this is usually machine dependent. In addition, there are a number of (non-fatal) "deliberate" errors in the program. A redundant equivalence statement was used in the subroutine "TABLAT" to make the code easier to write; these errors may be ignored if the computer will accept the code with non-fatal errors. Compile the ROSSRC file in the same way as for

the compilation of the LOADSRC program described above. The output from the compiler will point to the errors caused by the calls to the random number generator. Amend the ROSSRC code to the correct code for the new computer, noting that the random number generator code is designed to produce a real number in the range from zero to one, which is the normal output from a random number generator. At this stage, it may be wise to create a backup copy of the ROSSRC code on a different file to allow recovery if an error is made during file editing. The commands on the Harris computer are:

Command:	Effect:
GE, BACKUP	Generate a file called BACKUP
CO, ROSSRC, BACKUP	Copy the file ROSSRC to the new files called BACKUP

When these code changes have been made and an object program obtained, copy this object program onto the file ROSOBJ, which has been previously generated (see above).

Creating a ROS Model Job Stream File

Appendix E contains a listing of a job stream to run the ROS model. This job stream is similar to the one used to run the load program. In this instance, additional files are connected. ROS needs three temporary files with which to work, plus a file to place the printed output from the model. The user has an option

here; in this example, the output is sent directly to a physical device number 6, which for the Harris computer is the line printer; in this instance the printout is held on a temporary "SPOOL" file created by the operating system. Alternatively, the user may nominate a disk file, and when the model is run, the output will be stored there for later examination. Similarly, the work files can be disk files or temporary files; in the Harris operating system, these files are available during the running of the program and are released when the program ends. In some instances, the user may wish to retain the files for later examination. In Chapter 7 of the thesis, the verification process was described, and a suggestion made to use such files. Furthermore, the file attached to logical file 21 is the destination for the ROS option "unload"; when this option is invoked, either by the user or as a result of a data error, this file will usually need to be examined. The way to accomplish the retention of these files is to generate a file, then connect the logical file with the permanent disk files. A final point on the working files is important; the file attached to logical file 21 must be opened as a random access file. After the job stream is created, it can be saved on the file RUNROS, generated earlier.

A description of Appendix E follows:

Line:	Purpose:
MS	The macro starts
AS 6 = *	Connect diagnostic output from the model to the terminal
AS 21 = W2	Assign FORTRAN logical file 21 to a serial access work file
AS 23 = U3	Assign FORTRAN logical file 23 to a random access work file
AS 11 = ESTABDAT	Assign FORTRAN logical file 11 to the disk file Establishment Data
AS 12 = RAAFMEN	Assign FORTRAN logical file 12 to the disk file RAAF Manpower
AS 13 = SYSDATA	Assign FORTRAN logical file 13 to the disk file Systems data
AS 14 = COSTDATA	Assign FORTRAN logical file 14 to the disk file Cost data
AS 60 = *	Assign FORTRAN logical file 60 to the user's terminal response to the model
AS 61 = *	Assign FORTRAN logical file 61 to program's response to the user at the terminal
AS 66 = W3	Assign FORTRAN logical file 66 to a serial work file

AS 77 = :6	Assign FORTRAN logical file 77 to the physical device 6 which on the Harris computer is the line printer
ROSOBJ	Execute the program ROSOBJ
FR,ALL	Free all the assignments
ME	The macro ends

Again, note that these assignments are for the Harris computer operating system. The user must find the equivalent statements for the computer being used.

Running the ROS Model

Now comes the big moment! The load program has been written and compiled, its job stream created, the necessary destination data files opened, the job stream run to read the source tape, the ROS source program amended and compiled, and its job stream created. The user should ensure that the terminal "CAPS LOCK" is set, as the model expects all upper case responses. All that remains is to type "RUNROS" to invoke the model control job stream (for the Harris computer). If all has been done correctly, the user will be rewarded with the terminal printout:

"RAAF OFFICER STRUCTURE MODEL"

The ROS program next asks whether the model output is to be stored for later printing by asking:

"FILE TABLES FOR LATER PRINTOUT (Y/N)?"

At this stage, reply "N" to have the tables printed at the terminal. The program then reads all the model data from the attached data files. This process takes some time (about thirty seconds or so for the Harris computer), so be patient. This data reading process is a moment of truth, as the model will only proceed from here if all the files have been recovered from the tape without corruption. When (and if) the data is read in from the disk, the model will ask:

"WHAT IS THE ATS FOR 1981 ?"

The reply should be roughly equal to the Authorized Terminal Strength, 3650 is suggested. The model will then print a summary report of the Royal Australian Air Force Officer Corps, then request your option with the query:

"OPTIONS ARE: "G", "H=HELP", "Q", "U", "T", "E",
"C", "R"?"

Press "H" and return for an explanation of the options. The user may now branch to these options for a full examination of the model, using this trial data. Appendix F contains an example of this dialogue.

Copies of the Source Files. To assist any "debugging" that may be necessary, a complete listing of the source files is included in the appendices. An exception is the manpower file. Only the first few pages have

been included, as the full file, as listed, is 73 pages long. The files are:

Appendix:	File:
G	RAAF Officer Structure model source code
H	Cost data file
I	Establishment data file
J	Systems data file
K	RAAF officer data (partial file)

Data Input. A final word of caution on data entry is necessary. The ROS model expects data input to be made all in upper case, so use the terminal "CAPS LOCK" function. In addition, the model does not have a routine to check for "illegal" inputs such as numeric data when alpha-numeric is called for, and vice versa, so the user must be careful to enter a number, when one is requested and so forth. In some places, incorrect data entry will cause the model to stop running. Making the model "cretin proof" is fairly difficult in FORTRAN, as opposed to (say) BASIC, where there are functions which allow the necessary checks to be made. The problem is not great if some care is taken. The author has only made this mistake once in hundreds of runs; thus, after the user becomes familiar, there is little probability of an aborted run from this cause.

Problems

No detailed guidance will be given here on the solution to problems of installation. The programs "DUMP" and "LOAD" were tested on the Harris computer system and worked as described above. With the exception of the requirement to recode the random number calls, no changes to the model are envisaged as being necessary, provided the computer being used has a standard FORTRAN 77 compiler. Many new sections of the model were initially created on a Control Data CYBER 175 computer, test compiled on that machine using a FORTRAN 77 compiler, then the source code was dumped onto cards, re-entered into the Harris computer, and recompiled. (This was done because the author could create the necessary code on an "intelligent terminal" from home, and the Harris could not be used via a telephone while the CYBER could.) In no case was a problem encountered, leading to some confidence in the "portability" of the code.

If problems are encountered, the data files obtained from the tape should be checked against those contained here, as this could point to the problem. Thereafter, standard logical "debugging" techniques should be used to eliminate problems until the model is running.

Annex A--Chapter 2

OPERATIONAL USE OF THE RAAF OFFICER STRUCTURE MODEL

Introduction

The subject of this chapter is the operational use of the Royal Australian Air Force (RAAF) Officer Structure (ROS) model. The sources of data needed to run the model will be identified, and the methods of changing the data files to meet specific research requirements will be described.

Preparing the Model for Operational Use

In Chapter 4, the structure and function of the data files for the ROS model were discussed, with Figure 4.2 showing the interaction of the files and the model. The first step in using the model is to ensure that these files contain the best estimates of future events or constraints that are likely to effect the Officer Corps. One problem with strength management is that advice from many sources both within and outside the Royal Australian Air Force (RAAF) must be coalesced if accurate forecasts are to be produced. The provision of all the necessary advice from a single source is unlikely to be effective, as no single source is likely to have the

breadth and depth of knowledge that a combination of a variety of sources has. When producing manual estimates, combining this distributed wisdom is a difficult and time-consuming task. The great strength and power of the ROS model is its ability to merge this expert advice both quickly and accurately. In a simulation model of this type, once the effort has been expended to code all the necessary decision rules into the processing algorithm, providing new estimates is simply a matter of providing the model with new data and re-running the simulation. Thus, the first step is to describe the updating of this data base.

Establishment Data. (Appendix I contains an example of the Establishment data.) The primary determinant of the structure of the RAAF Officer Corps is the Establishment which reflects the number of officers, by Category and by rank, needed to complete all the tasks assigned to the RAAF. The Director of Organization and Establishment-Air Force is responsible for providing this data. Two forms of data are required: the present Establishment and the variations to the Establishment for each year the model will be run. This latter data is often difficult to generate, as it reflects the dynamic nature of the Service during the future, which depends on a causal chain starting with the strategic assessment.

Inevitably, a "best estimate" approach will be required. Another model, Force Variation Model (FORVAR), can automate the process of estimating the Establishment Changes. However, FORVAR does not provide establishment variations by rank within a Category; this needs to be done by the Directorate of Organization and Establishment staff. When the changes have been determined, they are applied to the Establishment file.

Manpower. (Appendix K contains a partial listing of the manpower file.) The data for the manpower file is obtained from the Officer Personnel data base. If the model is to be run from 1 January each year, then the data should be captured as early as possible in the calendar year, after the officer promotions take effect and before other changes such as wastage deplete the strength. (In the RAAF, the bulk of officer promotions take effect on 1 January.) The procedure is to have the data source computer create a magnetic tape with data on each officer serving on 1 January of the starting year. The variables time in rank, years of service, rank, Category, Branch, and significant change are written onto a magnetic tape (using a fixed format of six integers, each of three characters) that is compatible with the computer being used (e.g., 9 track, 800 bits per inch is one standard). This manpower data base MUST be sorted such that the primary key, rank, is decreasing, the secondary key, Category, is increasing, and time in rank,

the tertiary key, is decreasing. The ROS model processes each officer serially, making the necessary changes, and if the data base is out of order, then the model will malfunction. When the model starts, the order is checked; thereafter, the model maintains the correct order. When the data base is completed, it is read onto a disk file for use by the ROS model. Past experience by the author has shown that some editing is required. A few officers, usually 15 to 20, can be part of a Branch but not have a Category. An example is an officer on a pilot's course. The practice in this instance is to edit the officer's record to show the Category the officer will enter after completing training. Using the computer's text editor, the process only takes a few minutes. An alternative that has been used is to have a short program cross-check Branch and Category and prompt the operator to make the necessary amendments. Generating the data base in this manner saves a considerable amount of time in comparison to entering the data manually or, alternatively, manually updating the previous manpower data. Creating the manpower data base may be even easier in the future, as the Directorate of Personnel Officers-Air Force is (at the time of writing) installing a mini-computer with the necessary data on-line; when this data base is available, a program can be used to extract the manpower data and create the file for use by the ROS model.

System Data. (Appendix J contains a listing of the system data file.) The system data file contains a number of different parameters for the model. Obtaining this data will be described in the order that the data appears in the file. Note that some of the data will not need to be changed unless major structural changes are made to the Officer Corp. The base year should coincide with the date of the manpower data base creation. Years of service on recruitment should be examined to determine whether the numbers still represent the mean years of service that officers of each Category enter the RAAF with. This data can be obtained from analysis of officer recruitment data from one or more years prior to the creation of the manpower data base. Minimum time in rank for promotion is a policy matter and is usually directly available from the Directorate of Personnel Officers-Air Force personnel. An alternative source of data is an analysis of previous promotion results; the minimum time in rank can be set at the lowest actually experienced for the immediate prior promotions. Probability of promotion is probably best determined in this analytical manner. For each Category and for the ranks of Flight Lieutenant, Squadron Leader, and Wing Commander, the number promoted in a rank should be divided by those eligible for promotion (i.e., with a time in rank above the minimum time in rank for promotion and less than five years of time in rank above that time in

rank) to determine the probability of promotion. The probability of wastage is determined in a similar manner. The officers of the Service are divided into Branches, and within each Branch, into "bins" of years of service. The wastage data held by the Directorate of Personnel Officers-Air Force, the division of the wastage by the strength, will yield an estimate of the probability of wastage from that bin. The current practice is to use two years of data to provide a larger data source, and hence improvement of the accuracy of the estimation. Finally, the maximum number of recruits for each Category for each year the simulation will be run must be determined. This constraint for each Category will depend on several factors, e.g., the number of officer cadets presently in the training system, the amount of accommodation (for trainees) at present and in the future (e.g., new training facilities can allow more officer cadets to enter the Service, eventually yielding more officer recruits) and, finally, the number of civilians who will volunteer can also be a limiting factor. When these data are assembled, the system data file should be updated to reflect the change. This file is an example of the case where data from many sources is assembled for use by the model.

Cost Data. (Appendix H contains a listing of the cost data file.) The cost data file has two data sets:

the cost of "acquiring" an officer and the cost of each officer's salary. Acquisition costs include the cost of recruiting, plus the cost of training. Determining these costs can be very difficult, as the final costs depend on where one draws the boundary. For example, should pilot training costs include the cost of depreciation on the training aircraft, the cost of running the training base, the cost of supporting that base, etc? Clearly, these costs need to be subject to a policy decision, which, as yet, has not been made. (Remember that the purpose of this thesis is to provide a management tool, not ultimate decisions.) Salary costs include all allowances. For the rank of Flight Lieutenant, there are six pay levels that depend on time in rank. To ease the programming problem and allow for future pay structures, six pay levels have been included for all ranks. Thus, when less salary steps are present, the top figure is repeated until all six levels have been filled. In addition to these divisions, three tables, one for the General Duties Branch, one for Doctors and Dentists, and one for the rest of the officers, are included, to capture the different allowance structures. When entering salary data, the amounts for the ranks of Flying Officer to Air Vice Marshal are used, as well as the tables for direct entry officers. (Officers promoted from the ranks have a different salary scale while in the junior ranks.) These salary scales provide the best

estimate of costs as described in Chapter 6. Note that the data are entered in free format for this data file. The reason for this is to make the data entry relatively easy, as the salaries can change twice or more per year. Again, the computer text processor can be used to edit the data; alternatively, since the data is in free format and all the data is likely to change on an update, a new file can be built in the same format as the old.

Creating New Data Files

In the foregoing section of this chapter, editing the data files has been mentioned several times. This final section of the operations manual will suggest a method of completing this function. The sources of data have been identified above; once this data is available, the appropriate data file must be amended.

The first step should always be to make a backup copy of the file which will be worked on, then copy the original file to the backup file, thereby creating two identical files. If the editing process corrupts a file, recovery may be made by copying the spare copy back to the working copy. The method suggested here is to work on the copy "attached" to the model by the job control language "job stream" described in Chapter 1 of this annex. If this is done, it will not be necessary to change the job stream code that runs the model. The process of creating a spare

file is very simple (at least on the Harris mini-computer).

The operator types the following sequences:

Command:	Effect:
GE,SYSBKUP	Generate a new file called "SYSBKUP" which will (for example) be used to hold a version of the "SYSDATA" file.
CO,SYSDATA,SYSBKUP	Copy the old file "SYSDATA" to the new file "SYSBKUP"

After this is completed, two identical files, "SYSDATA" and "SYSBKUP" will be available to the operator.

At this point, a strong recommendation is to ensure that at least one "off-line" (i.e., a copy that must be manually loaded, and that is not accessible under program control) copy of the model, including the data files exists. Usually, the computer installation will have a utility program that will allow the operator to save machine language copies of data files on either magnetic tape or a disk pack. Good administrative procedures will ensure that a periodic backup of all files is made. However, if this is not the case, the programs "DUMP" and "LOAD," described in Chapter 1 of this annex, plus their associated job stream files, may be used to retain and reload a copy of the model. The "DUMPRUN" job stream is contained at Appendix B. The disadvantage of this method of saving copies of the model is that the process takes about 20 minutes to complete and uses most of a 2400-foot tape, while the machine

language utility usually completes a backup copy in a few seconds and only uses a fraction of the amount of tape. The reason is that the utility uses data compression techniques when saving the files.

The next step is to edit the file of interest (SYSDATA being used as an example). During the development of the model, the decision was made not to write special sections of the model to edit data, as this greatly increases the work involved in model maintenance; as the model is changed in any way that affects the data structure, a concomitant change to the editing code must be made. Most modern mini-computers have screen-oriented text processing editors available, and the use of such an editor is strongly recommended. The reason for this recommendation is that, with the exception of the COSTDATA file, a fixed format data is used. While this generally makes reading data into the model under program control a simple matter, it does place the onus on the operator to maintain the format during editing, as the loss of a single character can give a data error which can stop execution of the program. Using a full screen editor allows the operator to place the data over the old characters, without changing the spacing between the data elements that sets the format. The only possibility of error in this case is substitution of "O" for "0" and "I" for "1," or placing the decimal point in the wrong position. Care has been taken to ensure that the

data files have no more than 80 characters on a line and, where possible, data have been arranged in columns. Since most terminals used for text processing have at least a display width of 80 characters, no problems should be encountered when editing in this manner. If a screen editor is not available, then the normal line oriented text editors must be used. Great care must be exercised to maintain the data format in this instance. A suggestion is to print the data file before editing, then again after editing. Errors in the data structure are usually evident from a comparison of the printouts.

An example may be of assistance. The following method is applicable to the Harris mini-computer, but should be similar to other systems. Suppose we wish to change the wastage table in the SYSDATA file. Assuming the file has been backed up as described above, the operator logs onto the machine using one of the high-speed (9600 baud) visual display terminals. Next, the command "TX,SYSDATA" is issued. This command brings the file SYSDATA into the text processing mode, and the first few lines of the file are displayed on the screen. By pressing the "RETURN" key, the next page of line is displayed. The operator repeats this exercise until the wastage table is in view. This table is the 5 by 40 element array shown on the second page of Appendix J. Using the cursor movement keys on the terminal, the flashing cursor can be

placed over the characters to be changed, then the new characters are over-typed. The process of moving to a new page on the display and modifying the necessary characters is repeated until all editing is complete. The "HOME" key is then pressed and the command "UP" issued, which updates the original SYSDATA disk file. The text processor also allows insertions and deletions to be made if required; however, care should be taken to retain the original data structure for the reasons given above.

If the file is corrupted for any reason, recovery is quite simple; copy the backup file to the original file to return the system to its original state. The command in this example would be: "CO,SYSBKUP,SYSDATA." If both files are lost, then it will be necessary to recover a version of the file either from the DUMP/LOAD tape, or the machine language backup magnetic tape or disk pack. Finally, if all data is lost, it would be possible to rebuild the file using the text processor and the examples of the files listed in the appendices. In the most extreme case, the source program could be scanned to find the read statements. The latter two procedures are very labor and time-consuming; thus, the emphasis has been placed on retaining the copies of the data files provided with the model and amending them to meet the needs of the operator.

Having constructed a new file, the operator simply issues the command (e.g., "RUNROS" on the Harris

mini-computer) to run the job stream described in Chapter 1 of the Annex. Since the modified file is the original file "attached" to the model, no other changes need be made. When the run is over, the operator can return to the original state by copying the backup files back onto the originals. If a number of different types of runs are required, clearly, several versions of the data files can be created, retained, and copied to the appropriate file connected to the model.

Conclusions

The ROS model could be described as "data intensive" as every effort has been made to allow the operator to adapt the model for different research needs by changing the input data, rather than making changes to the source program. The opinion of the author is that this objective has been achieved, and that the model should remain useful for many years, without the need for program changes. However, the data files that "feed" the model must be regularly updated. Since the data format is fixed, great care must be taken to retain the correct format, or the model will malfunction or fail to execute. Use of both off-line and on-line backup of data files is highly recommended, as is the use of a full screen text processor to make changes to the data files.

APPENDIX A
DUMP SOURCE PROGRAM

PROGRAM DUMP

C THIS PROGRAM DUMPS THE ROS MODEL FILES ONTO MAGNETIC
C TAPE VIA A 135 CHARACTER BUFFER. NOTE THAT THREE COPIES
C ARE MADE IN CASE DIFFICULTIES ARISE READING ONE.
C THE USER MUST FIRST CONNECT THE MODEL FILES TO THE
C APPROPRIATE LOGICAL FILE NUMBERS 30, 40, 50, 60, 70,
C THE TAPE DRIVE TO 80, AND THE TERMINAL FOR MESSAGES.
C SUGGESTIONS ARE:

C 30 = ROSSRC (ROS SOURCE)
C 40 = SYSDATA (SYSTEMS DATA)
C 50 = ESTABDAT (ESTABLISHMENT DATA)
C 60 = RAAFMEN (OFFICER MANPOWER)
C 70 = COSTDATA (COST DATA)
C 80 = MAGNETIC TAPE DRIVE
C ?? = PRINT* TERMINAL

C DECLARE VARIABLES:
C CHARACTER*135 RECORD,BLANK

C
C REWIND 80

C
C FILL THE NECESSARY VARIABLES:
C 100 FORMAT(A135)
C 200 FORMAT('*EOR')

C
C DO 10 I = 1,135
C BLANK(I:I) = ' '
C 10 CONTINUE

C
C REPEAT THE DUMP FOR THREE CYCLES

C
C DO 80 I = 1,3
C PRINT*,' ----- DUMP CYCLE ',I,' -----'

C
C
C REWIND 30
C REWIND 40
C REWIND 50
C REWIND 60
C REWIND 70

C
C DUMP ROSSRC:
C PRINT*,' DUMPING ROSSRC.'
C 30 RECORD = BLANK
C READ(30,100,END=40) RECORD
C WRITE(80,100) RECORD
C GO TO 30

C
C DUMP SYSDATA:
C 40 PRINT*,' DUMPING SYSDATA.'

DUMP SOURCE PROGRAM.

PAGE # 2

```

      WRITE(80,200)
45    RECORD = BLANK
      READ(40,100,END=50) RECORD
      WRITE(80,100) RECORD
      GO TO 45
C
C DUMP ESTABDAT:
50    PRINT*, ' DUMPING ESTABDAT.'
      WRITE(80,200)
55    RECORD = BLANK
      READ(50,100,END=60) RECORD
      WRITE(80,100) RECORD
      GO TO 55
C
C DUMP RAAFMEN:
60    PRINT*, ' DUMPING RAAFMEN.'
      WRITE(80,200)
65    RECORD = BLANK
      READ(60,100,END=70) RECORD
      WRITE(80,100) RECORD
      GO TO 65
C
C DUMP COSTDATA:
70    PRINT*, ' DUMPING COSTDATA.'
      WRITE(80,200)
75    RECORD = BLANK
      READ(70,100,END=80) RECORD
      WRITE(80,100) RECORD
      GO TO 75
C
80    WRITE(80,200)
      CONTINUE
C
      PRINT*, ' '
      PRINT*, ' DUMP PROGRAM FINISHED.'
C
      REWIND 80
C
      END
```

APPENDIX B

DUMP MACRO

DUMP MACRO.

PAGE # 1

MS

AS 6 = *

AS 30 = ROSSRC

AS 40 = SYSDATA

AS 50 = ESTABDAT

AS 60 = RAAFMEN

AS 70 = COSTDAT

AS 80 = :10

DUMP08J

ME

APPENDIX C
PROGRAM TO LOAD ROS FILES

PROGRAM LOAD

C THIS PROGRAM LOADS THE ROS MODEL FILES FROM MAGNETIC
C TAPE VIA A 135 CHARACTER BUFFER. NOTE THAT THREE COPIES
C HAVE BEEN MADE IN CASE DIFFICULTIES ARISE READING ONE.
C THE USER MUST FIRST CONNECT THE MODEL FILES TO THE
C APPROPRIATE LOGICAL FILE NUMBERS 30, 40, 50, 60, 70,
C THE TAPE DRIVE TO 80, AND THE TERMINAL FOR MESSAGES.
C SUGGESTIONS ARE:

C 30 = ROSSRC (ROS SOURCE)
C 40 = SYSDATA (SYSTEMS DATA)
C 50 = ESTABDAT (ESTABLISHMENT DATA)
C 60 = RAAFMEN (OFFICER MANPOWER)
C 70 = COSTDATA (COST DATA)
C 80 = MAGNETIC TAPE DRIVE
C ?? = PRINT* TERMINAL

C DECLARE VARIABLES:
C CHARACTER*135 RECORD,BLANK

C FILL THE NECESSARY VARIABLES:
100 FORMAT(A135)

C DO 10 I = 1,135
C BLANK(I:I) = ' '
10 CONTINUE

C PRINT*, ' ----- LOADING THE FILES ----- '

C REWIND 30
C REWIND 40
C REWIND 50
C REWIND 60
C REWIND 70

C LOAD ROSSRC:
30 PRINT*, ' LOADING ROSSRC. '
35 RECORD = BLANK
C READ(80,100,END=40) RECORD
C IF(RECORD(1:4).EQ.'*EOR') GO TO 40
C WRITE(30,100) RECORD
C GO TO 35

C LOAD SYSDATA:
40 PRINT*, ' LOADING SYSDATA. '
45 RECORD = BLANK
C READ(80,100,END=50) RECORD
C IF(RECORD(1:4).EQ.'*EOR') GO TO 50
C WRITE(40,100) RECORD
C GO TO 45

PROGRAM TO LOAD POS FILES.

PAGE # 2

```
C
C LOAD ESTABDAT:
50  PRINT*, ' LOADING ESTABDAT.'
55  RECORD = BLANK
    READ(80,100,END=60) RECORD
    IF(RECORD(1:4).EQ.'*EOR') GO TO 60
    WRITE(50,100) RECORD
    GO TO 55

C
C LOAD RAAFMEN:
60  PRINT*, ' LOADING RAAFMEN.'
65  RECORD = BLANK
    READ(80,100,END=70) RECORD
    IF(RECORD(1:4).EQ.'*EOR') GO TO 70
    WRITE(60,100) RECORD
    GO TO 65

C
C LOAD COSTDATA:
70  PRINT*, ' LOADING COSTDATA.'
75  RECORD = BLANK
    READ(80,100,END=80) RECORD
    IF(RECORD(1:4).EQ.'*EOR') GO TO 80
    WRITE(70,100) RECORD
    GO TO 75

C
80  CONTINUE
C
    PRINT*, ' '
    PRINT*, ' LOAD PROGRAM FINISHED.'
C
    END
```

APPENDIX D
PROGRAM LOAD JOB STREAM

PROGRAM LOAD JOB STREAM.

PAGE # 1

MS
AS 6 = *
AS 30 = ROSSRC
AS 40 = SYSDATA
AS 50 = ESTABDAT
AS 60 = RAAFMEN
AS 70 = COSTDATA
AS 80 = :10
LOADOBJ
ME

APPENDIX E
RAAF OFFICER STRUCTURE MODEL MACRO

RAAF OFFICER STRUCTURE MODEL MACRO.

PAGE # 1

MS

AS 6 = *

AS 21 = W2

AS 23 = U3

AS 11 = ESTABDAT

AS 12 = RAAFMEN

AS 13 = SYSDATA

AS 14 = COSTDAT

AS 60 = *

AS 61 = *

AS 66 = W3

AS 77 = 86

ROSOBJ

FR,ALL

ME

APPENDIX F
AN EXAMPLE OF DIALOGUE WITH THE COMPUTER

RUNROS

RAAF OFFICER STRUCTURE MODEL

FILE TABLES FOR LATER PRINTOUT (Y/N)?

Y

WHAT IS THE ATS FOR 1981 ?

3650

-1 MEN LEFT OVER IN INITIAL ALLOCATION

TOOK ONE BACK FROM FLTLT AIR TRAFFIC

0 MEN LEFT OVER IN FINAL ALLOCATION

ATS USED= 3650

1981 (BASE YEAR)

	PLTOFF/							TOTAL
RANK	FLGOFF	FLTLT	SQNLDR	WGCDR	GPCAPT	AIRCDR	AVM	
STRENGTH	913	1388	787	408	104	33	14	3647
TARGET	1123	1126	822	421	115	31	12	3650
ESTABLISHMENT	1208	1229	876	428	115	31	12	3899

OPTIONS ARE: "G", "H=HELP", "Q", "U", "T", "E", "C", "R"

?

H

EXPLANATIONS OF OPTIONS ARE:

"G" MEANS "GO" (ADVANCES THE MODEL)

"H" MEANS "HELP" (PRINTS THIS MESSAGE)

"Q" MEANS "QUIT" (STOPS THE PROGRAM)

"U" MEANS "UNLOAD" (DUMPS MAN INFO ONTO FILE FTN21)

"T" MEANS "TABULATE" (TABULATES ANY ATTRIBUTE BY RANK)

"E" MEANS "ESTAB" (SHOWS ESTAB & NO. BORNE BY CATGRY)

"C" MEANS "COSTING" (PRESENTS THE ANNUAL COSTS)

"R" MEANS "RESTART" (BEGINS AGAIN FROM THE BASE YEAR)

OK NOW YOU KNOW THE CODES

OPTIONS ARE: "G", "H=HELP", "Q", "U", "T", "E", "C", "R"

?

G

WHAT IS THE WASTAGE FACTOR FOR THE YEAR 1981

.85

WHAT IS THE ATS FOR 1982 ?

3700

-1 MEN LEFT OVER IN INITIAL ALLOCATION

TOOK ONE BACK FROM FLGOFF EQUIPMENT

0 MEN LEFT OVER IN FINAL ALLOCATION

ATS USED= 3700

APPENDIX G
RAAF OFFICER STRUCTURE MODEL PROGRAM

C CONTROL LOCATION, BOUNDS

C CONTROL SEGMENT=SEG1

PROGRAM ROS

C FUNCTIONS OF THE VARIOUS SUBROUTINES CALLED HERE ARE -
C SETUP READS ESTAB, INIT AND SYS PARAM FILES (LU11,12,13)
C NEXTYE STEPS A YEAR AND DOES THE CALCULATIONS
C TABLAT TABULATES CURRENT STATUS
C ESTABC DISPLAYS NO BORNE AND ESTABLISHMENT BY CATEGORY
C GETFIL SETS UP INPUT FILES AND LIST FILES
C GETSYSNAMES SETS UP NAMES OF SYSTEM PARAMETERS
C COSTING DETERMINES THE COST OF THE OFFICER CORPS INC TRAINING
C

COMMON /MANC / TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
INTEGER TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
COMMON /BLANK / TIME,TOTAL,NEXTLK,NOINRA(7),NOBORNE(7,25)
INTEGER TIME,TOTAL
COMMON /ESTABL / ESTABL(7,25),ESTRKN(7),ESTCAT(25),ESTOT,
- TARGET(7,25),RNKTGT(7),ATS,INLMAN(7,25),
- NCANDS(3,25)
INTEGER ESTABL,ESTRKN,ESTCAT,ESTOT,TARGET,RNKTGT,ATS
COMMON /SYSTEM / NRANKS,NCATS,LOOKIN,INITYE,ISCALE,WASFAC,
- NBRCHS,BRCHCT(25),
- MINTIM(7,25),PROTAB(3,25),
- WASTAB(5,40),JPRINT,KPRINT
INTEGER BRCHCT
COMMON /RECRUT / IYOSRC(25),MAXREC(25),NUMREC(7,25)
COMMON /TABULN / MINTAB(6),MAXTAB(6)
COMMON /INOUT / IOCORE(7,5000),LASTRC
COMMON /WASTE / NEWAST
REAL NEWAST
COMMON /NAMES / RANKNM(7),CATNAM(25),BRCHNM(5),SIGNAM(5)
CHARACTER*1 RANKNM*6, CATNAM*15, BRCHNM*15, SIGNAM*15
COMMON /COUNTS / IWAS(7),IRET(7),IREC(7),IPRO(7),IEXIT(25)
CHARACTER*1 COMMAND
WRITE(61,*) ' '
WRITE(61,*) ' RAAF OFFICER STRUCTURE MODEL '
WRITE(61,*) ' '
C OPTIONALLY DISPOSE OF PRINTOUT OF TABLES
JPRINT = 61
WRITE(61,*) ' FILE TABLES FOR LATER PRINTOUT (Y/N)? '
READ(60,40) COMMAND
WRITE(61,*) ' '
IF (COMMAND.EQ.'Y') JPRINT = 77
KPRINT = JPRINT
REWIND 77
C

RANKNM(1)='FLGOFF'
RANKNM(2)='FLTLT'
RANKNM(3)='SGNLDR'
RANKNM(4)='WGCDR'

```

RANKNM( 5)='GPCAPT'
RANKNM( 6)='AIRCOR'
RANKNM( 7)='  AVM'
CALL GETSYS
10 CALL SETUP
20 WRITE (61,30)
30 FORMAT(/' OPTIONS ARE: "G","H=HELP","Q","U","T","E","C","R"/
  ' ?')
  READ (60,40) COMMAND
40 FORMAT(A1)
  IF (COMMAND.NE.'H') GO TO 60
  WRITE (61,50)
50 FORMAT(' EXPLANATIONS OF OPTIONS ARE:/'
  ' "G" MEANS "GO"           (ADVANCES THE MODEL)'/
  ' "H" MEANS "HELP"        (PRINTS THIS MESSAGE)'/
  ' "Q" MEANS "QUIT"        (STOPS THE PROGRAM)'/
  ' "U" MEANS "UNLOAD"      (DUMPS MAN INFO ONTO FILE FTN21)'/
  ' "T" MEANS "TABULATE"    (TABULATES ANY ATTRIBUTE BY RANK)'/
  ' "E" MEANS "ESTAB"       (SHOWS ESTAB & NO. BORNE BY CATGRY)'/
  ' "C" MEANS "COSTING"     (PRESENTS THE ANNUAL COSTS)'/
  ' "R" MEANS "RESTART"     (BEGINS AGAIN FROM THE BASE YEAR)'/
  ' OK NOW YOU KNOW THE CODES')
  GO TO 20
60 IF (COMMAND.NE.'G') GO TO 80
  NEXTLK = TIME + LOOKIN
  C
  C
  SET WASTAGE FACTOR FOR THE YEAR
  WRITE(61,*) ' WHAT IS THE WASTAGE FACTOR FOR THE YEAR ',TIME
  READ(60,*) NEWAST
  C
70 CALL NEXTYE
  IF (TIME.LT.NEXTLK) GO TO 70
  GO TO 20
80 IF(COMMAND.EQ.'Q') STOP ' COLLECT MODEL OUTPUT?'
  IF(COMMAND.EQ.'U') CALL UNLOAD
  IF(COMMAND.EQ.'T') CALL TABLAT
  IF(COMMAND.EQ.'E') CALL ESTABC
  IF(COMMAND.EQ.'C') CALL COSTS
  IF(COMMAND.EQ.'R') GO TO 10
  GO TO 20
END
CCONTROL SEGMENT=SEG2
  C
  C
  SUBROUTINE GETFIL (NOT USED IN THIS IMPLEMENTATION)
  C
  C
  THIS SUBROUTINE SETS UP FILE EQUATIONS FOR ALL FILES
  C
  C
  USED DURING ALL PHASES OF THE PROGRAM.
  C
  C
  THE FILES ARE:
  C
  C
  FTN21: A PERMANENT FILE, OUTPUT IN RESPONSE TO A 'UNLOAD'
  C
  COMMAND. (NOT AN INPUT FILE.)

```

```

C          IT IS IN THE SAME FORMAT AS FILE FTN12 (IE 613).
C          IT IS SIMPLY A DUMP OF ALL OF ARRAY IOCORE(7,5000).
C      FTN23: RECRUITS FILE CREATED DURING RUN, NOT AN INPUT FILE
C      FTN11: ESTABLISHMENT FILE. CONTAINS :
C              ESTABLISHMENT LEVELS FOR EACH RANK AND BRANCH, CHANGES
C              MUST BE REPEATED WITH THE APPROPRIATE
C              VALUES FOR EACH YEAR THAT THE MODEL WILL BE RUN
C      FTN12: MANPOWER FILE, CONTAINS ONE RECORD PER OFFICER.
C      FTN13: SYSTEM PARAMETERS FILE. CONTAINS VALUES FOR ALL
C              SYSTEM PARAMETERS (SUCH AS RATES FOR RECRUITMENT,
C              WASTAGE, PROMOTION ETC.).
C      FTN14: COST OF SALARIES AND TRAINING
C      FTN60: SYSTEM INPUT FILE. i.e. WHAT YOU TYPE WHEN YOU RUN
C              THE MODEL.
C      FTN61: SYSTEM OUTPUT FILE. i.e. THE RESULTS OF YOUR TYPING,
C              AND PROMPTS FOR MORE COMMANDS.
C      FTN66: PLACE WHERE RETIREES GO, NOT AN INPUT FILE
C      FTN77: A SPOOL FILE FOR THE PRINTED OUTPUT
C
C      RETURN
C      END
C      CCONTROL BOUNDS
C      CCONTROL SEGMENT=SEG2
C      SUBROUTINE SETUP
C
C      THIS SUBROUTINE ACQUIRES (OR REQUIRES IN THE CASE OF A "RESTART")
C      THE DATA USED BY THE MODEL:
C      LU11 HAS THE ESTABLISHMENT NUMBERS
C      LU12 HAS THE "INITIAL CONDITIONS" I.E. RECORDS OF OFFICERS
C              SERVING IN THE BASE YEAR
C      LU13 HAS THE SYSTEM PARAMETERS
C
C      COMMON /MANC / TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
C      INTEGER      TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
C      COMMON /BLANK / TIME,TOTAL,NEXTLK,NOINRA(7),NOBRNE(7,25)
C      INTEGER      TIME,TOTAL
C      COMMON /ESTABL / ESTABL(7,25),ESTRNK(7),ESTCAT(25),ESTOT,
C      -              TARGET(7,25),RNKTGT(7),ATS,INLMAN(7,25),
C      -              NCANDS(3,25)
C      INTEGER      ESTABL,ESTRNK,ESTCAT,ESTOT,TARGET,RNKTGT,ATS
C      COMMON /SYSTEM / NRANKS,NCATS,LOOKIN,INITYE,ISCALE,WASFAC,
C      -              NBRCHS,BRCHCT(25),
C      -              MINTIM(7,25),PROTAB(3,25),
C      -              WASTAB(5,40),JPRINT,KPRINT
C      INTEGER      BRCHCT
C      COMMON /RECRUT / IYOSRC(25),MAXREC(25),NUMREC(7,25)
C      COMMON /TABULN / MINTAB(6),MAXTAB(6)
C      COMMON /INOUT / IOCORE(7,5000),LASTRC
C      COMMON /WASTE / NEWAST
C      REAL          NEWAST

```

```

COMMON /NAMES / RANKNM(7),CATNAM(25),BRCHNM(5),SIGNAM(5)
CHARACTER*1      RANKNM*6, CATNAM*15, BRCHNM*15,SIGNAM*15
COMMON /COUNTS / IWAS(7),IRET(7),IREC(7),IPRO(7),IEXIT(25)

C
LOGICAL FIRST
DATA FIRST/,TRUE./
IF (FIRST) GO TO 20
WRITE (61,10)
10 FORMAT(' **** MODEL RESTARTING FROM INITIAL YEAR ****'//)
20 FIRST=.FALSE.
REWIND 11
REWIND 12
REWIND 13

C
C
C READ IN SYSTEM PARAMETERS

READ(13,31) NRANKS
READ(13,31) NCATS
READ(13,31) LOOKIN
READ(13,31) INITYE
READ(13,31) ISCALE
READ(13,30) WASFAC
30 FORMAT(F5.1)
READ(13,31) NBRCHS
31 FORMAT(I5)
READ(13,32)(BRCHNM(I),I=1,NBRCHS)
READ(13,32)(SIGNAM(I),I=1,5)
32 FORMAT(5A15)
READ(13,34)(MINTAB(I),I=1,6)
READ(13,34)(MAXTAB(I),I=1,6)
34 FORMAT(6I5)
READ(13,36)(IYOSRC(I),I=1,NCATS)
36 FORMAT(25I3)
READ(13,37)((MINTIM(I,J),I=1,NRANKS),J=1,NCATS)
37 FORMAT(7I5)
READ(13,38)((PROTAB(I,J),I=1,3),J=1,NCATS)
38 FORMAT(3F5.2)
READ(13,39)((WASTAB(I,J),I=1,NBRCHS),J=1,40)
39 FORMAT(5F5.3)
READ(13,36)(MAXREC(I),I=1,NCATS)

C
C
C READ IN ESTABLISHMENT SIZES, BRANCH NUMBERS AND CATEGORY NAMES

READ (11,40) ((ESTABL(I,J),I=1,NRANKS),BRCHCT(J),CATNAM(J),J=1,
-NCATS)
40 FORMAT(7I3,4X,I3,A15)
ZERO THE RECRUITING ARRAY

C
C
DO45 I=1,NRANKS
DO 47 J=1,NCATS

```

NUMREC(I,J)=0
47 CONTINUE
45 CONTINUE

C
C
C
C
C
C
C

READ IN INITIAL CONDITIONS FILE

THE FILE SHOULD BE SORTED ALREADY IN ORDER OF:

RANK - DECREASING
CATEGORY - INCREASING
TIME IN RANK - DECREASING

LASTRK=99
LASTCT=0
LASTTR=99
TOTAL=0
LASTRC=0
DO 60 I = 1,NRANKS
DO 50 J = 1,NCATS
50 NOBRNE(I,J)=0
60 NOINRA(I)=0
70 READ (12,80,END=140) TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH
80 FORMAT(6I3)
LGBLTY=TIMERA-MINTIM(RANK,CATGRY) +1
IF(LGBLTY.LT.0)LGBLTY=7
IF(LGBLTY.GT.5)LGBLTY=7
IF (RANK-LASTRK) 130,90,110
90 IF (LASTCT-CATGRY) 130,100,110
100 IF (TIMERA-LASTTR) 130,130,110
110 WRITE (61,120) LASTRK,LASTCT,LASTTR,TOTAL,TIMERA,YOS,RANK,
*CATGRY,BRANCH,SIGCH
120 FORMAT(// '** OFFICER DATA INPUT FILE OUT OF SEQUENCE **'//
*'LAST RECORD - RANK=',I3,' LAST CATEGORY=',I3,' LAST TIME IN RANK'
*,I3,' RECORD NO.=',I4/'THIS RECORD (TIMERA,YOS,RANK,CAT,BR,SIGCH)'
*,6I3)
STOP
130 LASTRK=RANK
LASTCT=CATGRY
LASTTR=TIMERA
TOTAL = TOTAL + 1
LASTRC=LASTRC+1
NOINRA(RANK) = NOINRA(RANK) + 1
NOBRNE(RANK,CATGRY)=NOBRNE(RANK,CATGRY)+1
CALL OUT(TOTAL)
GO TO 70

C
C
C

ADD UP ESTAB & NOS 'BORNE IN BASE YEAR

140 ESTOT = 0
DO 150 JT = 1,NCATS
150 ESTCAT(JT)=0

```

DO 170 IT = 1, NRANKS
ESTRNK(IT)=0
DO 160 JT = 1, NCATS
MENEST=ESTABL(IT, JT)
ESTRNK(IT)=ESTRNK(IT)+MENEST
160 ESTCAT(JT)=ESTCAT(JT)+MENEST
170 ESTOT = ESTOT +ESTRNK(IT)

C
C SET TIME FOR NEXT LOOK
C SET WASTAGE FACTOR TO 1
C
TIME=INITYE
NEXTLO = TIME+LOOKIN
NEWAST=WASFAC

C
C CALL ALLCAT TO READ INITIAL TERMINAL STRENGTH (FTN60)
C AND ALLOCATE TARGETS THROUGH ALL RANKS AND CATEGORIES
C
CALL ALLCAT

C
C WRITE (77,180) TIME,TOTAL,NOINRA
C 180 FORMAT(9I5)
C
C PRINT OUT ESTABS AND NUMBERS BORNE IN INITIAL YEAR
C
CALL PRTOU
RETURN
END
CCONTROL SEGMENT=SEG1
CCONTROL JOUNDS
SUBROUTINE OUT(J)

C
C THIS ROUTINE TAKES THE CURRENT SEVEN WORDS OF COMMON
C BLOCK "MANC" - DATA ON THE CURRENT OFFICER -
C AND ENCODES IT INTO ARRAY IOCORE(7,5000)
C
COMMON /MANC / TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
INTEGER TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
COMMON /SYSTEM / NRANKS,NCATS,LOOKIN,INITYE,ISCALE,WASFAC,
- NBRCHS,BRCHCT(25),
- MINTIM(7,25),PROTAB(3,25),
- WASTAB(5,40),JPRINT,KPRINT
INTEGER BRCHCT
COMMON /INOUT / IOCORE(7,5000),LASTRC
IF(J.LE.0)STOP 'J.LE.0 IN OUT'
IF(J.GT.LASTRC)STOP 'J.GT.LASTRC IN OUT'
IF(J.GT.5000)PRINT*, 'J.GT.5000 IN OUT',J
IOCORE(1,J)=TIMERA
IOCORE(2,J)=YOS
IOCORE(3,J)=RANK

```

```

        IOCORE(4,J)=CATGRY
        IOCORE(5,J)=BRANCH
        IOCORE(6,J)=SIGCH
        IOCORE(7,J)=LGBLTY
        IF (RANK.EQ.0) GO TO 10
        IF (CATGRY.EQ.0) GO TO 10
        IF (BRANCH.EQ.0) GO TO 10
        IF (YOS.GT.40) GO TO 10
        IF (RANK.GT.NRANKS) GO TO 10
        IF (CATGRY.GT.NCATS) GO TO 10
        IF (BRANCH.GT.5) GO TO 10
        RETURN
10 PRINT*, ' VALUE OUT OF RANGE, J=',J,'; LASTRC=',LASTRC
    PRINT*, 'TIMER',TIMER
    PRINT*, 'YOS',YOS
    PRINT*, 'RANK',RANK
    PRINT*, 'CATEGORY',CATGRY
    PRINT*, 'BRANCH',BRANCH
    PRINT*, 'SIGCH',SIGCH
    CALL UNLOAD
    STOP 'OFFICER DATA DUMPED TO FTN21'
    END
CCONTROL SEGMENT=SEG1
CCONTROL BOUNDS
    SUBROUTINE IN(J)
C
C      THIS ROUTINE TAKES THE Jth ELEMENT OF ARRAY
C      IOCORE(7,5000) AND DECODES IT INTO
C      SEVEN INTEGERS IN THE COMMON BLOCK MANC.
C      THIS CONSTITUTES THE DATA ON THE OFFICER
C      CURRENTLY BEING INSPECTED.
C
COMMON /MANC / TIMER, YOS, RANK, CATGRY, BRANCH, SIGCH, LGBLTY
INTEGER      TIMER, YOS, RANK, CATGRY, BRANCH, SIGCH, LGBLTY
COMMON /INOUT / IOCORE(7,5000), LASTRC
IF(J.GT.LASTRC) STOP 'J.GT.LASTRC IN IN'
TIMER=IOCORE(1,J)
YOS=IOCORE(2,J)
RANK=IOCORE(3,J)
CATGRY=IOCORE(4,J)
BRANCH=IOCORE(5,J)
SIGCH=IOCORE(6,J)
LGBLTY=IOCORE(7,J)
RETURN
END
CCONTROL SEGMENT=SEG1
CCONTROL BOUNDS
    SUBROUTINE UNLOAD
C
C      THIS SUBROUTINE DUMPS ALL OF THE OFFICER DATA ONTO DISC.

```

C

CONTROL BOUNDS

SUBROUTINE RESEQ

```
COMMON /MANC / TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
INTEGER TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
COMMON /BLANK / TIME,TOTAL,NEXTLK,NOINRA(7),NOBRNE(7,25)
INTEGER TIME,TOTAL
COMMON /SYSTEM / NRANKS,NCATS,LOOKIN,INITYE,ISCALE,WASFAC,
NBRCHS,BRCHCT(25),
MINTIM(7,25),PROTAB(3,25),
WASTAB(5,40),JPRINT,KPRINT
INTEGER BRCHCT
COMMON /RECRUT / IYOSRC(25),MAXREC(25),NUMREC(7,25)
COMMON /INOUT / IOCORE(7,5000),LASTRC
```

n n n n n n n n n n n n n n n n

THIS ROUTINE TAKES THE OFFICER DATA FILE (ARRAY IOCORE) AT THE END OF A YEAR'S SIMULATION (OR AT THE START OF THE NEXT YEAR) AND SORTS IT INTO THE CORRECT SEQUENCE. THE INPUT DATA WAS IN THE CORRECT ORDER, BUT SOME OFFICERS HAVE BEEN PROMOTED, SOME HAVE WASTED OR RETIRED, AND THERE IS A LARGE LUMP OF RECRUITS ON THE END. THIS ROUTINE DROPS THE WASTAGE, PUSHES THE PROMOTEEES UP THE LINE, AND PUTS THE RECRUITS ONTO THE END OF THE APPROPRIATE RANK-CATEGORY BUNDLES (WHICH ARE SORTED INTO DECREASING ORDER OF SENIORITY).

THE FIRST PART DELETES THE WASTED OFFICERS AND RECRUITS, REMEMBERING THAT THERE IS AN ARRAY (NUMREC) WITH THE NUMBER OF RECRUITS IN EACH CATEGORY. THE PROMOTEES ARE WRITTEN OUT ONTO FILE PTN23, FOR LATER RETRIEVAL. THESE BLOKES WILL ALL JUMP UP ONE RANK, SO THEY ARE IN THE CORRECT SEQUENCE ALREADY. THE DECREASED SIZED DATA FILE IS SQUASHED DOWN TOWARDS THE BOTTOM TO ALLOW A BLANK SPACE AT THE TOP OF THE DATA ARRAY.

THE SECOND PART OF THE ROUTINE MERGES THE THREE DATA SOURCES, THE LARGE DATA ARRAY, THE PROMOTEES WHO WERE


```

C          PUSHED ONTO FILE FTN23, AND THE RECRUITS WHOSE NUMBERS
C          ARE HELD IN ARRAY NUMREC.
      INTEGER BUF(7),CORBUF(7),OCRBUF(7),BUF3(7),RECBUF(7)
      EQUIVALENCE (BUF(1),TIMERA),(BUF(2),YOS),(BUF(3),RANK),
*                (BUF(4),CATGRY),(BUF(5),BRANCH),(BUF(6),SIGCH),
*                (BUF(7),LG8LTY)
      OPEN(UNIT=23,STATUS='SCRATCH',ACCESS='DIRECT',
*FORM='UNFORMATTED',RECL=30,BLANK='NULL')
      NREC3=0
      NREAD=LASTRC
      NWRITE=LASTRC
10  IF (NREAD.EQ.0) GO TO 30
      CALL IN(NREAD)
      NREAD=NREAD-1
      IF (SIGCH.GE.4) GO TO 10
      IF (SIGCH.NE.3) GO TO 20
      NREC3=NREC3+1
      WRITE(23,REC=NREC3) BUF
      GO TO 10
20  IF (SIGCH.EQ.2) GO TO 10
      CALL OUT(NWRITE)
      NWRITE=NWRITE-1
      GO TO 10
30  NREAD=NWRITE+1
      NWRITE=1

```

```

C
C
C
C

```

SECOND PART
MERGE THE OLD LIST, THE PROMOTEES AND RECRUITS,
PUSHING THE LIST BACK UP TO THE TOP OF THE ARRAY.

```

      LAST=0
      CALL IN(NREAD)
      NREAD=NREAD+1
      DO 40 I = 1,7
40  CORBUF(I)=BUF(I)
      IF(NREC3.NE.0)READ(23,REC=NREC3)BUF3
      DO 140 IRANK = NRANKS,1,-1
      DO 140 ICAT = 1,NCATS
      IF (LAST.EQ.1) GO TO 100
      DO 50 I = 1,7
50  BUF(I)=CORBUF(I)
60  IF (ICAT.NE.CATGRY) GO TO 80
      IF (IRANK.NE.RANK) GO TO 80
      CALL OUT(NWRITE)
      NWRITE=NWRITE+1
      IF (NREAD.GT.LASTRC) GO TO 70
      CALL IN(NREAD)
      NREAD=NREAD+1
      GO TO 60
70  LAST=1

```

```

      GO TO 100
    80 DO 90 I = 1,7
      CORBUF(I)=BUF(I)
    90 CONTINUE
  C
    100 IF (NREC3.EQ.0) GO TO 120
      IF (BUF3(3).NE.IRANK) GO TO 120
      IF (BUF3(4).NE.ICAT) GO TO 120
      DO 110 I = 1,7
    110 BUF(I)=BUF3(I)
      CALL OUT(NWRITE)
      NWRITE=NWRITE+1
      NREC3=NREC3-1
      IF (NREC3.EQ.0) GO TO 120
      READ(23,REC=NREC3)BUF3
      GO TO 100
  C
    120 II=NUMREC(IRANK,ICAT)
      NUMREC(IRANK,ICAT) = 0
      IF (II.EQ.0) GO TO 140
      RANK=IRANK
      CATGRY=ICAT
      BRANCH=BRCHCT(ICAT)
      TIMERA=0
      YOS=0
      SIGCH=2
      DO 130 I = 1,II
      CALL OUT(NWRITE)
      NWRITE=NWRITE+1
    130 CONTINUE
    140 CONTINUE
      CLOSE(23)
      LASTRC=NWRITE-1
      IF(LASTRC.EQ.TOTAL)RETURN
      PRINT*, ' LASTRC,NE.TOTAL',LASTRC, ' NE',TOTAL
      STOP'IN RESEG'
      END
CCONTROL BOUNDS
CCONTROL SEGMENT=SEG1
SUBROUTINE PRTOU
COMMON /BLANK / TIME,TOTAL,NEXTLK,NOINRA(7),NOBRNE(7,25)
INTEGER TIME,TOTAL
COMMON /ESTABL / ESTABL(7,25),ESTRNM(7),ESTCAT(25),ESTOT,
- TARGET(7,25),RNKTGT(7),ATS,INLMAN(7,25),
- NCANDS(3,25)
INTEGER ESTABL,ESTRNM,ESTCAT,ESTOT,TARGET,RNKTGT,ATS
*
COMMON /SYSTEM / NRANKS,NCATS,LOOKIN,INITYE,ISCALE,WASFAC,
- NBRCHS,BRCHCT(25),
- MINTIM(7,25),PROTAB(3,25),

```

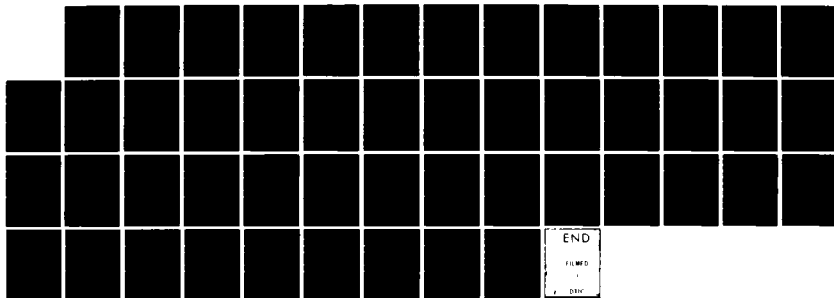
AD-A122 847

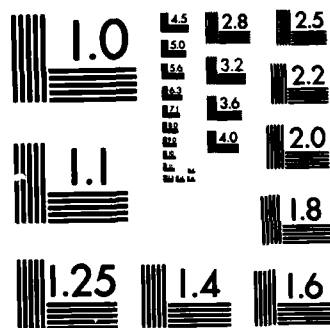
A COMPUTER SIMULATION OF THE STRUCTURE OF THE ROYAL
AUSTRALIAN AIR FORCE. (U) AIR FORCE INST OF TECH
WRIGHT-PATTERSON AFB OH SCHOOL OF SYST. C L MILLS
SEP 82 AFIT-LSSR-15-82 F/G 5/1

4/4

UNCLASSIFIED

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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-
      WASTAB(5,40),JPRINT,KPRINT
      INTEGER
      BRCHCT
      COMMON /NAMES / RANKNM(7),CATNAM(25),BRCHNM(5),SIGNAM(5)
      CHARACTER*1 RANKNM*6, CATNAM*15, BRCHNM*15,SIGNAM*15
      COMMON /COUNTS / IWAS(7),IRET(7),IREC(7),IPRO(7),IEXIT(25)

C
      CHARACTER*11 BASE

C
      BASE=' '
      IF (TIME.EQ.INITYE)BASE='(BASE YEAR)'
      WRITE (61,10) TIME,BASE,RANKNM,NOINRA,TOTAL,RNKTGT,ATS,ESTRNM
      *,ESTOT
10  FORMAT(' ',I4,1X,A11/13X,'PLTOFF/',4X,'TOTAL',/ ' RANK',8X,7(1X,A6)
      */ ' STRENGTH',4X,8I7/ ' TARGET',6X,8I7/ ' ESTABLISHMENT',16,7I7/)
      IF (TIME.EQ.INITYE)RETURN
      WRITE (61,20) IPRO,IREC,IRET,IWAS
20  FORMAT(' COUNTS OF OFFICERS PROMOTED AND NEW RECRUITS: ' /
      * ' PROMOTIONS ',7I7/ ' RECRUITS ',7I7/ /
      * ' COUNTS OF OFFICERS EXITING: ' / ' RETIRED ',5X,7I7/ ' WASTED ',6X,7I7)
      RETURN
      END

CCONTROL LOCATION
CCONTROL BOUNDS
CCONTROL SEGMENT=SEG3
      SUBROUTINE NEXTYE

C
C
C
C
C
C
      CALCULATE THE CHANGES IN EACH MAN'S STATUS OVER THE PAST
      TIME INTERVAL. EACH MAN'S RECORD IS READ IN AND THEN WRITTEN
      OUT UNLESS HE HAS LEFT THE AIR FORCE.
      NEW RECRUITS ARE THEN INTRODUCED.

      COMMON /MANC / TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
      INTEGER
      TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
      COMMON /BLANK / TIME,TOTAL,NEXTLK,NOINRA(7),NOBRNE(7,25)
      INTEGER
      TIME,TOTAL
      COMMON /ESTABL / ESTABL(7,25),ESTRNM(7),ESTCAT(25),ESTOT,
      TARGET(7,25),RNKTGT(7),ATS,INLMAN(7,25),
      NCANDS(3,25)
      INTEGER
      ESTABL,ESTRNM,ESTCAT,ESTOT,TARGET,RNKTGT,ATS
      COMMON /SYSTEM / NRANKS,NCATS,LOOKIN,INITYE,ISCALE,WASFAC,
      NBRCHS,BRCHCT(25),
      MINTIM(7,25),PROTAB(3,25),
      WASTAB(5,40),JPRINT,KPRINT
      INTEGER
      BRCHCT
      COMMON /RECRUT / IYOSRC(25),MAXREC(25),NUMREC(7,25)
      COMMON /INOUT / IOCORE(7,5000),LASTRC
      COMMON /NAMES / RANKNM(7),CATNAM(25),BRCHNM(5),SIGNAM(5)
      CHARACTER*1 RANKNM*6, CATNAM*15, BRCHNM*15,SIGNAM*15
      COMMON /COUNTS / IWAS(7),IRET(7),IREC(7),IPRO(7),IEXIT(25)

```

```

DIMENSION IATOLD(6),INESTB(7)

C
C
C      RESEQ OFFICER DATA IN CORE,
C      DELETING WASTED AND RETIRED OFFICERS.
C      SEQUENCE IS:      RANK (DESCENDING)
C                        CATEGORY (ASCENDING)
C                        TIME IN RANK (DESCENDING)
C
IF (TIME .NE. INITYE) CALL RESEQ

C
C
C      STEP TIME AND RESET PARAMETERS FOR THE
C      START OF A NEW YEAR

REWIND 66
TIME = TIME + 1

C
C
DO 10 CATGRY = 1,NCATS
DO 5 IRKLS1=1,3
5 NCANDS(IRKLS1,CATGRY)=0
IEXIT(CATGRY)=0
DO 10 RANK = 1,NRANKS
10 NUMREC(RANK,CATGRY)=0
DO 20 RANK = 1,NRANKS
IWAS(RANK)=0
IREC(RANK)=0
IPRO(RANK)=0
20 IRET(RANK)=0
GO TO 50
40 WRITE (61,*) ' *** END OF INFORMATION ON ESTAB FILE ***'
WRITE (61,*) ' I SUGGEST YOU USE A DIFFERENT COMMAND'
RETURN
C
C      READ IN CHANGES TO ESTABLISHMENT NUMBERS

50 DO 70 ICAT = 1,NCATS
READ (11,60,END=40) INESTB
60 FORMAT(7I5)
DO 70 RANK = 1,NRANKS
INC = INESTB(RANK)
ESTABL(RANK,ICAT) = ESTABL(RANK,ICAT)+INC
ESTRKN(RANK) = ESTRKN(RANK)+INC
ESTCAT(ICAT)=ESTCAT(ICAT)+INC
70 ESTOT = ESTOT+INC
GO TO 75
C
C      READ THE RECRUITING LIMIT FOR THE YEAR

72 WRITE(61,*) ' *** END OF INFORMATION ON THE SYSTEMS FILE ***'
WRITE(61,*) ' I SUGGEST YOU USE A DIFFERENT COMMAND'
RETURN
C
75 READ(13,76,END=72)(MAXREC(I),I=1,NCATS)

```

76 FORMAT(25I3)

C
C
CALLCAT MANPOWER TARGETS AS A FRACTION OF ESTABLISHMENT
CALL ALLCATC
C
C

SET UP INITIALIZATION FOR THIS YEAR

C
C
C

CALL ANS(1, IANSWER)

C
C
C

NOW LOOK AT EACH MAN IN TURN

IF (TOTAL.EQ.0) GO TO 150

DO 80 RANK = 1, NRANKS

DO 80 CATGRY = 1, NCATS

80 INLMAN(RANK, CATGRY)=0

LASTRK=99

LASTCT=0

DO 140 I = 1, LASTRC

C
C
C

GET NEXT MAN'S RECORD

CALL IN(I)

C
C
C

SAVE OLD ATTRIBUTE VALUES

IATOLD(1)=TIMERA

IATOLD(2)=YOS

IATOLD(3)=RANK

IATOLD(4)=CATGRY

IATOLD(5)=BRANCH

IATOLD(6)=SIGCH

C
C
C

FIND FIRST MAN IN EACH RANK-CATEGORY GROUP

IF (CATGRY.EQ.LASTCT.AND.RANK.EQ.LASTRK) GO TO 90

LASTRK=RANK

LASTCT=CATGRY

INLMAN(RANK, CATGRY)=I

C
C
C

UPDATE TIME DEPENDENT ATTRIBUTES

90 CALL ANS(2, IANSWER)

C
C
C

CHECK WHETHER MAN RETIRES

C
C
CTHERE IS NO SPECIFIC TABLE GOVERNING RETIRING CONDITIONS
IT IS SUFFICIENTLY ACCURATE TO SAY THAT WHEN AN OFFICER
RUNS OFF THE END OF THE WASTAGE TABLE THEN HE RETIRESC
C
C

IF (YOS.LE.40) GO TO 100

SIGCH=4

IRET(RANK)=IRET(RANK)+1

IEXIT(CATGRY)=IEXIT(CATGRY)+1

GO TO 110

270

```

C
C   CHECK WHETHER MAN HAS WASTED OUT
100 CALL ANS(3, IANSWER)
    IF (IANSWER.EQ.1) GO TO 110
C
C   CALCULATE ELIGIBILITY FOR PROMOTION (&SUM CANDIDATES IN RANKS 2-4)
    CALL ANS(4, IANSWER)
    GO TO 120
C
C   MAN LEAVES THE AIR FORCE
110 NOINRA(RANK) = NOINRA(RANK) - 1
    NOBRNE(RANK, CATGRY) = NOBRNE(RANK, CATGRY) - 1
    TOTAL = TOTAL - 1
120 IF (SIGCH.NE.1) WRITE (66, 130) IATOLD, TIMERA, YOS, RANK, CATGRY,
    -BRANCH, SIGCH
130 FORMAT(12I5)
C   MAN STILL NEEDED ON FILE, EVEN IF WASTED
C   SO WRITE OUT HIS UPDATED RECORD
    CALL OUT(I)
140 CONTINUE
C
C   CALL ANS TO GO THRU THE 'PROMOTION BOARD SIMULATION'
C   ON RETURN, ALL PROMOTIONS HAVE BEEN EFFECTED
    CALL ANS(5, IANSWER)
C
C   INTRODUCE ALL THE RECRUITS
150 CALL ANS(6, IANSWER)
C
C   RESET TOTAL NUMBER OF MEN IN THE AIR FORCE
C   AND DISPLAY NUMBERS OF MEN IN EACH RANK
    TOTAL = 0
    DO 160 RANK = 1, NRANKS
160 TOTAL = TOTAL + NOINRA(RANK)
C
C   CALL PRTOU
C
C   WRITE (66, 170) TIME
170 FORMAT(' END OF YEAR', I5)
    RETURN
    END
CCONTROL BOUNDS, LOCATION
CCONTROL SEGMENT=SEG3
    SUBROUTINE ANS(INDEX, IANSWER)
C
C   THIS IS THE SUBROUTINE WHICH HAS THE LOGIC FOR
C   UPDATING TIME DEPENDENT ATTRIBUTES, CHECKING WHETHER
C   AN OFFICER EXITS THROUGH RETIREMENT OR WASTAGE.
C   IT ALSO HAS THE CODE TO PROMOTE OFFICERS AND INTRODUCE RECRUITS.

```


C
C
C
C

NEW RECRUITS ARE INTRODUCED BY CREATING RECORDS HAVING
THE ATTRIBUTE VALUES DICTATED BY CALLS FROM NEXTYE.

```

COMMON /MANC / TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
INTEGER TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
COMMON /BLANK / TIME,TOTAL,NEXTLK,NOINRA(7),NOBRNE(7,25)
INTEGER TIME,TOTAL
COMMON /ESTABL / ESTABL(7,25),ESTRKN(7),ESTCAT(25),ESTOT,
TARGET(7,25),RNKTGT(7),ATS,INLMAN(7,25),
NCANDS(3,25)
INTEGER ESTABL,ESTRKN,ESTCAT,ESTOT,TARGET,RNKTGT,ATS
*
COMMON /SYSTEM / NRANKS,NCATS,LOOKIN,INITYE,ISCALE,WASFAC,
NBRCHS,BRCHCT(25),
MINTIM(7,25),PROTAB(3,25),
WASTAB(5,40),JPRINT,KPRINT
INTEGER BRCHCT
COMMON /RECRUT / IYOSRC(25),MAXREC(25),NUMREC(7,25)
COMMON /INOUT / IOCORE(7,5000),LASTRC
COMMON /WASTE / NEWAST
REAL NEWAST
COMMON /NAMES / RANKNM(7),CATNAM(25),BRCHNM(5),SIGNAM(5)
CHARACTER*1 RANKNM*6, CATNAM*15, BRCHNM*15, SIGNAM*15
COMMON /COUNTS / IWAS(7),IRET(7),IREC(7),IPRO(7),IEXIT(25)

```

C

```

LOGICAL PROM
INTEGER SHRTGE(25),TOTSHY
CHARACTER*1 TABLYN
DATA TABLYN/'Y'/

```

C

```

IANSWER=0
GO TO (10,30,40,50,60,210), INDEX
10 WRITE (66,20) TIME
20 FORMAT(' SIGNIFICANT CHANGES FOR YEAR ',I4)
RETURN

```

C
C
C

UPDATE OFFICER'S ATTRIBUTES (UPDATE)

```

30 TIMERA=TIMERA+1
YOS=YOS+1
SIGCH=1
RETURN

```

C
C
C
C
C
C

CHECK FOR OFFICER WASTING OUT

```

AN OFFICER WILL WASTE OUT AS A FUNCTION OF HIS/HER
YEARS OF SERVICE AND BRANCH
PROBABILITY OF WASTING = WASTAB(BRANCH,YOS)

```

```

40 IF(YOS,GT,39) GO TO 45
   IF(RANU(0,0,1,0),GT,WASTAB(BRANCH,YOS)*NEWAST) RETURN
45 CONTINUE
   IANSWER=1
   SIGCH=4
   IEXIT(CATGRY)=IEXIT(CATGRY)+1
   IWAS(RANK)=IWAS(RANK)+1
   RETURN

```

```

C
C
C CALCULATE OFFICER'S ELIGIBILITY FOR PROMOTION

```

```

C
C   ELIGIBILITY IS EQUIVALENT TO THE NUMBER OF TIMES THE OFFICER
C   HAS COME UP FOR CONSIDERATION BEFORE THE PROMOTIONS BOARD.
C   WHEN HIS TIME IN RANK IS EQUAL TO THE MINIMUM, THEN IT'S
C   HIS FIRST TIME AND "LGBLTY"=1.
C   IF HE'S BEEN ELIGIBLE FOR MORE THAN FIVE YEARS, SET HIS
C   ELIGIBILITY GREATER THAN 5.
50 LGBLTY=TIMER-A-MINTIM(RANK,CATGRY) +1
   IF(LGBLTY,LT,0,OR,LGBLTY,GT,5)LGBLTY=7
   IF(LGBLTY,LT,1,OR,LGBLTY,GT,5)RETURN
   IF(RANK,LT,2,OR,RANK,GT,4)RETURN
   NCANDS(RANK-1,CATGRY)=NCANDS(RANK-1,CATGRY)+1
   RETURN

```

```

C
C   PROMOTIONS!
C   THIS BIT SIMULATES THE PROMOTION BOARD.
C   PARTICULARLY FOR THE MIDDLE RANKS, IT DIVIDES THE ELIGIBLE
C   OFFICERS INTO ELIGIBILITY "BINS", DEPENDING ON TIME IN RANK
C   AND MINIMUM TIME IN RANK (ONE SET OF BINS FOR EACH RANK-
C   CATEGORY GROUPING), AS EACH BLOKE FAILS TO GET PROMOTED,
C   HE MOVES INTO THE NEXT HIGHER BIN FOR THE NEXT YEAR. WHEN
C   HE GETS PAST BIN FIVE, HE IS NO LONGER CONSIDERED,
C   FOR EACH YEAR AND FOR EACH RANK-CATEGORY GROUPING,
C   AN ELIGIBLE MAN HAS A PROBABILITY OF BEING
C   PROMOTED OF ABOUT 70% (DEPENDING ON THE VALUES IN "PROTAB").
C   AYM's DON'T GET PROMOTED.
C   AIRCDRE's AND GPCAPT's WILL BE PROMOTED IF THERE'S A VACANCY.
C   FLGOFF's GET PROMOTED AT MINTIM WHETHER THERE'S A VACANCY
C   OR NOT.

```

```

C
C   LOOK FOR FIRST AIRCDRE
60 DO 70 ICAT = 1,NCATS
   IF (INLMAN(6,ICAT),NE,0) GO TO 80
70 CONTINUE

```

```

C
C   AIRCDRE AND GPCAPT (RANK=6 OR 5) GET PROMOTED IF THEY ARE
C   ELIGIBLE AND THERE'S A VACANCY.
80 MAN=INLMAN(6,ICAT)-1
90 MAN=MAN +1
   CALL IN(MAN)

```

```

100 IF (RANK.LT.5) GO TO 110
C   IF NOT ELIGIBLE, LOOK AT THE NEXT ONE.
   IF (SIGCH.GE.4) GO TO 90
   IF (LGBLTY.LE.0) GO TO 90
   IF (LGBLTY.GT.5) GO TO 90
C   IF NO VACANCY, GO TO NEXT BLOKE.
   IF (NOBRNE(RANK+1,CATGRY).GE.TARGET(RANK+1,CATGRY)) GO TO 90
C   OK, PROMOTE HIM.
   CALL PROMTM(MAN)
   GO TO 90

C   WGCORE, SQNLDR, FLTLT (RANK=4,3,2) HAVE TO FIGHT FOR
C   PROMOTION.
110 DO 180 IRANK = 4,2,-1
   DO 180 ICAT = 1,NCATS
   IF (INLMAN(IRANK,ICAT).EQ.0) GO TO 180
   IVACANT=TARGET(IRANK+1,ICAT)-NOBRNE(IRANK+1,ICAT)
   IF (IVACANT.LE.0) GO TO 180
   ICAND=NCANDS(IRANK-1,ICAT)
   CAND=ICAND*PROTAB(IRANK-1,ICAT)
   ICAND=CAND
   IF (RANU(0.0,1.0).LT.(CAND-ICAND)) ICAND=ICAND+1
   IVACANT=MIN(IVACANT,ICAND)
   PROB=PROTAB(IRANK-1,ICAT)
C   SCAN THRU EACH GROUP TILL THE FIRST ELIGIBLE MAN IS FOUND
DO 130 LOOKMAN = INLMAN(IRANK,ICAT),TOTAL
CALL IN(LOOKMAN)
IF (CATGRY.NE.ICAT) GO TO 180
IF (SIGCH.GE.4) GO TO 130
IF (LGBLTY.LE.0) GO TO 130
IF (LGBLTY.GT.5) GO TO 130
GO TO 140
130 CONTINUE
C   RAN OUT OF MEN!??*
GO TO 180
C   SCAN THRU ALL THE MEN IN BINS 1 TO 5
140 DO 160 MAN = LOOKMAN,LASTRC
   IF (IVACANT.LE.0) GO TO 180
   CALL IN(MAN)
   IF (RANK.NE.IRANK) GO TO 160
   IF (CATGRY.NE.ICAT) GO TO 170
   IF (SIGCH.GE.4) GO TO 160
   IF (LGBLTY.GT.5) GO TO 160
   IF (LGBLTY.LE.0) GO TO 160
   PROM=.FALSE.
   IF (RANU(0.0,1.0).LE.PROB) PROM=.TRUE.
   IF (.NOT.PROM) GO TO 160
   CALL PROMTM(MAN)
   IVACANT=IVACANT-1
160 CONTINUE

```

```

C      FLG0FF (RANK=1) HAVE AUTOMATIC PROMOTION IF THEY HAVE
C      MINIMUM TIME IN RANK FOR THAT CATEGORY.
C      DO 200 ICAT = 1,NCATS
C      MAN1=INLMAN(1,ICAT)
C      IF (MAN1.EQ.0) GO TO 200
C      DO 190 MAN = MAN1,LASTRC
C      CALL IN(MAN)
C      IF (CATGRY.NE.ICAT) GO TO 200
C      IF (SIGCH.GE.4) GO TO 190
C      IF (LGBLTY.LE.0) GO TO 190
C      IF (LGBLTY.GT.5) GO TO 190
C      CALL PROMTM(MAN)
190  CONTINUE
200  CONTINUE
      RETURN

```

NOW INTRODUCE RECRUITS

SO FAR WE HAVE DONE OUR RETIRING, WASTING, PROMOTING
AND AGING OF OFFICERS.
WE HAVE KEPT TRACK OF NUMBERS IN NOBRNE(RANK,CATGRY)
AND NOINRA(RANK) THROUGH ALL OF THIS.

ADD RECRUITS IN THE LOWEST ALLOWABLE RANK IN EACH CATEGORY UP TO THE LIMIT OF TARGET(RANK,CATGRY) IN EACH CASE.
THE NUMBER OF RECRUITS WILL NOT EXCEED IEXIT(CATGRY) WHICH IS THE SUM OF WASTAGE PLUS ESTAB INCREASES.
THE CASES WHERE RECRUITS JOIN AT FLTLT INSTEAD OF FLGOFF OR PLTOFF ARE SIGNALLED BY ZERO VALUES FOR MINTIM(1,CATGRY).

INITIALIZE

210 TIMERA=0
TOTSHT=0
SIGCH=2

PROCESS THE RECRUITS ON A CATEGORY BY CATEGORY BASIS
NO ACCOUNT IS TAKEN OF LIMITS ON NUMBERS OF RECRUITS
BY BRANCH, (TRAINING ACCOMMODATION LIMIT)

```
DO 260 CATGRY = 1,NCATS
  BRANCH=BRCHCT(CATGRY)
  YOS=IYOSRC(CATGRY)
  RANK=1
  IF(MINTIM(RANK,CATGRY).EQ.0)RANK=2
  NRECS=0
```

```

SHRTGE(CATGRY)=0
DO 220 IRANK = 1, NRANKS
220 NRECS=NRECS+TARGET(IRANK,CATGRY)-NOBRNE(IRANK,CATGRY)
    LIM=MAXREC(CATGRY)
    ISHORT=NRECS-LIM
    IF (ISHORT.LE.0) GO TO 230
    SHRTGE(CATGRY)=ISHORT
    NRECS=LIM
    TOTSHT=TOTSHT+ISHORT
230 IF (NRECS.LE.0) GO TO 260
    NUMREC(RANK,CATGRY)=NRECS
    IREC(RANK)=IREC(RANK)+NRECS
    NOBRNE(RANK,CATGRY)=NOBRNE(RANK,CATGRY)+NRECS
    NOINRA(RANK)=NOINRA(RANK)+NRECS
    DO 250 IT = 1, NRECS
    TOTAL=TOTAL+1
    WRITE (66,240) TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH
240 FORMAT(30X,6I5)
    LASTRC=LASTRC+1
250 CALL OUT(LASTRC)
260 CONTINUE
    IF(TOTSHT.LE.0)RETURN
270 WRITE (61,280)
280 FORMAT(// ' THE FOLLOWING SHORTAGES WERE CAUSED BY RECRUITING ',
    * ' LIMITS' )
    DO 300 ICAT = 1, NCATS
    IF (SHRTGE(ICAT).LE.0) GO TO 300
    WRITE (61,290) ICAT,CATNAM(ICAT),SHRTGE(ICAT)
290 FORMAT(' CATEGORY',I3,' ', 'A15,' SHORT BY',I3)
300 CONTINUE
    WRITE (61,310) TOTSHT
310 FORMAT(10X,'TOTAL SHORTAGE WAS',I4//)
    IF(TIME.NE.INITYE+1)GO TO 312
    WRITE (61,311)
311 FORMAT(// ' IN ORDER TO HELP YOU RE-ALLOCATE THE RECRUIT SHORTAGES'
    * ' I CAN PRINT THE COMPLETE MANNING AND ESTABLISHMENT TABLE'
    * ' OR I CAN SUPPRESS IT FOR THE REST OF THE RUN.'
    * ' DO YOU WANT IT? (Y/N) ' // '?')
    READ (60,400) TABLYN
400 FORMAT(A1)
312 IF(TABLYN.EQ.'Y')THEN
    JPRINT = 61
    CALL ESTABC
    JPRINT = KPRINT
    END IF
    WRITE (61,320)
320 FORMAT(// ' HOW DO YOU WANT TO REALLOCATE THE RECRUIT SHORTAGES?'
    * ' TYPE IN A SERIES OF LINES, EACH LINE CONTAINING TWO NUMBERS,'
    * ' A CATEGORY NUMBER AND THE NUMBER OF EXTRA RECRUITS TO FORCE'
    * ' ON THAT CATEGORY. ' // ' FINISH WITH TWO ZEROS IE 0 0.' )

```

```

330  CATGRY=0
      NRECS=0
      WRITE (61,*) ' ?'
      READ (60,*) CATGRY,NRECS
      IF (CATGRY*NRECS.LE.0) RETURN
      IF (NRECS.LE.TOTSHT) GO TO 340
      WRITE (61,*) ' THAT WAS TOO MANY, YOU'VE ONLY GOT',TOTSHT,'LEFT'
      GO TO 330
340  TOTSHT=TOTSHT-NRECS
      YOS=IYOSRC(CATGRY)
      BRANCH=BRCHCT(CATGRY)
      RANK=1
      IF (MINTIM(RANK,CATGRY).EQ.0) RANK=2
      NUMREC(RANK,CATGRY)=NUMREC(RANK,CATGRY)+NRECS
      IREC(RANK)=IREC(RANK)+NRECS
      NOBRNE(RANK,CATGRY)=NOBRNE(RANK,CATGRY)+NRECS
      NOINRA(RANK)=NOINRA(RANK)+NRECS
      DO 350 IT = 1,NRECS
      TOTAL=TOTAL+1
      WRITE (66,240) TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH
      LASTRC=LASTRC+1
      CALL OUT(LASTRC)
350  CONTINUE
      IF (TOTSHT.GT.0) GO TO 330
      RETURN
      END
CCONTROL BOUNDS
CCONTROL SEGMENT=SEG3
      SUBROUTINE PROMTM(MAN)
      COMMON /MANC / TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
      INTEGER      TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
      COMMON /BLANK / TIME,TOTAL,NEXTLK,NOINRA(7),NOBRNE(7,25)
      INTEGER      TIME,TOTAL
      COMMON /COUNTS / IWAS(7),IRET(7),IREC(7),IPRO(7),IEXIT(25)

      C      OFFICER HAS BEEN SET UP FOR PROMOTION.
      C      PROMOTE HIM. DO THE BOOK-KEEPING.
      NOINRA(RANK)=NOINRA(RANK)-1
      NOBRNE(RANK,CATGRY)=NOBRNE(RANK,CATGRY)-1
      RANK=RANK+1
      NOINRA(RANK)=NOINRA(RANK)+1
      NOBRNE(RANK,CATGRY)=NOBRNE(RANK,CATGRY)+1
      LGBLTY=7
      TIMERA=0
      SIGCH=3
      IPRO(RANK)=IPRO(RANK)+1
      CALL OUT(MAN)
      RETURN
      END
CCONTROL BOUNDS

```

SUBROUTINE ALLCAT

INTEGER TIMERA, YOS, RANK, CATGRY, BRANCH, SIGCH, LGBLTY

INTEGRAL	TIME, TOTAL
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25
26	26
27	27
28	28
29	29
30	30
31	31
32	32
33	33
34	34
35	35
36	36
37	37
38	38
39	39
40	40
41	41
42	42
43	43
44	44
45	45
46	46
47	47
48	48
49	49
50	50
51	51
52	52
53	53
54	54
55	55
56	56
57	57
58	58
59	59
60	60
61	61
62	62
63	63
64	64
65	65
66	66
67	67
68	68
69	69
70	70
71	71
72	72
73	73
74	74
75	75
76	76
77	77
78	78
79	79
80	80
81	81
82	82
83	83
84	84
85	85
86	86
87	87
88	88
89	89
90	90
91	91
92	92
93	93
94	94
95	95
96	96
97	97
98	98
99	99
100	100

TARGET(7,25),RNKTGT(7),ATS,INLMAN(7,25),

INTEGER ESTABL, ESTRNK, ESTCAT, ESTOT, TARGET, RNKTGT,

NBRCHS, BRCHCT (25),

WASTAB(5,40),JPRINT,KPRINT

COMMON / NAMES / RANKNM(7), CATNAM(25), BRCHNM(5), SIGNAM(5)

INTEGER ESTLFT,BIGR,BIGC,SMLR,SMLC

AND DIVIDES IT UP AMONGST THE RANKS AND CATEGORIES

THE DISTRIBUTION IS AS A PROPORTION OF ESTABLISHMENT

GENERAL DUTIES BRANCH:- 100%

GPCAPT AND HIGHER:- 100%

WGCDR:- 96%

THE REMAINDER IS ALLOCATED TO UN-ALLOCATED FLTLTs AND FLGOFFs

THEREFORE NOT GUARANTEED COMPLETE ACCURACY!

PROPORTIONS WILL NOT NECESSARILY ADD UP TO THE

REQUIRED FIGURES FOR THE 96% AND 92% GROUPS OR THE TOTAL:

ZERO TARGET AND RANKTARGET

MENLFT=0

```
10 00 20 RANK = 1, NRANKS
```

RNKTGT(RANK)=0

00 20 CATGRY = 1, NCATS

20 TARGET(RANK,CATGRY)=0

READ AUTHORISED STRENGTH FROM ESTABLISHMENT FILE

WRITE (61,*) 'WHAT IS THE ATS FOR',TIME,'?'

READ (60,*) AT.S

ALLCAT 100% TO GD BRANCH (CATEGORIES 1 AND 2)

00 40 CATGRY = 1,2

```

DO 40 RANK = 1, NRANKS
MEN=ESTABL(RANK,CATGRY)
TARGET(RANK,CATGRY)=MEN
RNKTGT(RANK)=RNKTGT(RANK)+MEN
40 CONTINUE

```

```

C
C      NOW PROCESS REMAINDER IN LOOP TO 80
DO 80 CATGRY = 3, NCATS
IF (ESTCAT(CATGRY).GE.36) GO TO 60

```

```

C
C      FIRST THE SMALL CATEGORIES
DO 50 RANK = 1, NRANKS
MEN=ESTABL(RANK,CATGRY)
TARGET(RANK,CATGRY)=MEN
RNKTGT(RANK)=RNKTGT(RANK)+MEN
50 CONTINUE
GO TO 80

```

```

C
C      NOW THE BIG CATEGORIES, GOING DOWN TO SQNLDR
60 DO 70 RANK = 5, NRANKS
MEN=ESTABL(RANK,CATGRY)
TARGET(RANK,CATGRY)=MEN
RNKTGT(RANK)=RNKTGT(RANK)+MEN
70 CONTINUE

```

```

C
MEN=ESTABL(4,CATGRY)*0.96+0.5
TARGET(4,CATGRY)=MEN
RNKTGT(4)=RNKTGT(4)+MEN

```

```

C
MEN=ESTABL(3,CATGRY)*0.92+0.5
TARGET(3,CATGRY)=MEN
RNKTGT(3)=RNKTGT(3)+MEN
80 CONTINUE

```

```

C
C      FIND OUT HOW MANY MEN LEFT FOR RANKS 1 AND 2
MENLFT=ATS

```

```

C
C      SUBTRACT ALL MEN ALREADY ALLCATD
DO 90 RANK = 1, NRANKS
90 MENLFT=MENLFT-RNKTGT(RANK)

```

```

C
C      FIND HOW MANY ESTABLISHMENT POSITIONS LEFT FOR THEM
ESTLFT=0
DO 100 RANK = 1, 2
DO 100 CATGRY = 3, NCATS
IF (ESTCAT(CATGRY).LT.36) GO TO 100
ESTLFT=ESTLFT+ESTABL(RANK,CATGRY)
100 CONTINUE

```

```

C
C      FIND FRACTION TO APPORTION TARGETS TO RANKS 1 AND 2
FRCLFT=FLOAT(MENLFT)/FLOAT(ESTLFT)

```



```

C
C      SET UP FOR END ADJUSTMENT (WHEREIN WE ADD OR SUBTRACT ONE
C      MAN TO ALLOW FOR THE IMPERFECT ALLOCATION. THE MAN ADDED
C      OR SUBTRACTED IS IN THE RANK-CATEGORY NEAREST TO BEING
C      ROUNDED UP OR DOWN IN THE ORIGINAL SHUFFLE).
      BIGFRC=0.0
      SMLFRC=1.0
      DO 130 RANK = 1,2
      DO 130 CATGRY = 3,NCATS
      IF (ESTCAT(CATGRY).LT.36) GO TO 130
      REAL=ESTABL(RANK,CATGRY)*FRCLFT+0.5
      MEN=REAL
      FRACRL=REAL-FLOAT(MEN)

C
C      FRACRL IS BETWEEN 0.0 AND 1.0
      IF (FRACRL.EQ.0.0) GO TO 120
      IF (FRACRL.GT.SMLFRC) GO TO 110
      SMLFRC=FRACRL
      SMLR=RANK
      SMLC=CATGRY
110  IF (FRACRL.LT.BIGFRC) GO TO 120
      BIGFRC=FRACRL
      BIGR=RANK
      BIGC=CATGRY
120  TARGET(RANK,CATGRY)=MEN
      RNKTGT(RANK)=RNKTGT(RANK)+MEN
      MENLFT=MENLFT-MEN
130  CONTINUE
      IF (MENLFT.EQ.0) RETURN
      WRITE (61,*) MENLFT,'MEN LEFT OVER IN INITIAL ALLOCATION'
      IF (MENLFT.GT.0) GO TO 140
      WRITE (61,*) 'TOOK ONE BACK FROM ',RANKNM(SMLR),CATNAM(SMLC)
      TARGET(SMLR,SMLC)=TARGET(SMLR,SMLC)-1
      RNKTGT(SMLR)=RNKTGT(SMLR)-1
      MENLFT=MENLFT+1
      GO TO 150
140  WRITE (61,*) 'GAVE ONE MORE TO ',RANKNM(BIGR),CATNAM(BIGC)
      TARGET(BIGR,BIGC)=TARGET(BIGR,BIGC)+1
      RNKTGT(BIGR)=RNKTGT(BIGR)+1
      MENLFT=MENLFT-1
150  ATS=ATS-MENLFT
      WRITE (61,*) MENLFT,'MEN LEFT OVER IN FINAL ALLOCATION'
      WRITE(61,*) 'ATS USED=',ATS
      RETURN
      END
CCONTROL BOUNDS
CCONTROL SEGMENT=SEG4
      SUBROUTINE TABLAT
C
C      THIS SUBROUTINE PRODUCES TABLATIONS OF NUMBERS OF OFFICERS

```

C IN THE 7 RANKS HAVING VARIOUS VALUES OF THE PERSONAL ATTRIBUTES
 C (I.E. LENGTH OF SERVICE, BRANCH, TIME IN RANK, ETC)
 C

```
COMMON /MANC / TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
INTEGER TIMERA,YOS,RANK,CATGRY,BRANCH,SIGCH,LGBLTY
COMMON /BLANK / TIME,TOTAL,NEXTLK,NOINRA(7),NOBRNE(7,25)
INTEGER TIME,TOTAL
COMMON /INOUT / IOCORE(7,5000),LASTRC
COMMON /SYSTEM / NRANKS,NCATS,LOOKIN,INITYE,ISCALE,WASFAC,
- NRCHS,BRCHCT(25),
- MINTIM(7,25),PROTAB(3,25),
- WASTAB(5,40),JPRINT,KPRINT
INTEGER BRCHCT
COMMON /TABULN / MINTAB(6),MAXTAB(6)
COMMON /NAMES / RANKNM(7),CATNAM(25),BRCHNM(5),SIGNAM(5)
CHARACTER*1 RANKNM*6, CATNAM*15, BRCHNM*15, SIGNAM*15
INTEGER TABLE(7,50),ATTRIB(7),CWIDTH,SUBTOT(7)
EQUIVALENCE (ATTRIB,TIMERA),(VARNAM,BRCHNM),
- (VARNAM(1,2),SIGNAM)
CHARACTER*15 VARNAM(5,2)
INTEGER VARCON,HICON
```

C

```
CHARACTER*1 REP
CHARACTER*28 VARDSC(6)
LOGICAL WASTIN
DATA VARDSC/'TIME IN RANK (YEARS)',
- 'LENGTH OF SERVICE(YEARS)',
- 'CATEGORY',
- 'BRANCH',
- 'SIGNIFICANT CHANGE INDICATOR',
- 'ELIGIBILITY FOR PROMOTION'/
10 WRITE (61,20)
20 FORMAT (' TABLATE ON WHICH VARIABLE NUMBER?',
- ' - ENTER 0 TO HAVE OPTIONS DISPLAYED',
- ' (ENTER THE NUMBER -1 TO LEAVE THE "TABLATE" MODE)',
- ' ?')
30 IVAR=-1
READ (60,*) IVAR
IF (IVAR.GT.0) GO TO 50
IF (IVAR.EQ.-1) RETURN
WRITE (61,40) (I,VARDSC(I),I=1,6)
40 FORMAT(6(I3,' : ',A28/)) PLEASE ENTER YOUR CHOICE'/' ?')
GO TO 30
50 IF (IVAR.GE.1.AND.IVAR.LE.6) GO TO 60
WRITE (61,160)
GO TO 10
60 M3 = MINTAB(IVAR)-1
M2 = MAXTAB(IVAR)-M3
DO 70 I = 1,M2
DO 70 J = 1,NRANKS
```

```

70 TABLE(J,I) = 0
   IF (TOTAL.GT.0) GO TO 100
80 WRITE (61,90)
90 FORMAT('/' NOTHING TO TABLATE!'/)
   RETURN
100 I1MIN=99
   I1MAX=0
   IIVAR=IVAR
   IF(IIVAR.GE.3)IIVAR=IIVAR+1
   WASTIN=.FALSE.
   IVARCN=0
110 WRITE (61,120)
120 FORMAT(' IS THE TABLATION TO BE CONFINED IN ANY WAY (Y/N)?'/' ?')
   READ (60,130) REP
130 FORMAT(A1)
   IF (REP.EQ.'N') GO TO 190
   IF (REP.EQ.'Y') GO TO 140
   WRITE (61,*) ' IF YOU CAN'T ANSWER YES OR NO,'
   WRITE (61,*) ' I WON'T LET YOU PLAY MY GAME!'
   GO TO 110
140 WRITE (61,150)
150 FORMAT(' ENTER VARIABLE NUMBER BY WHICH SUBSET IS CHOSEN'/' ?')
   READ (60,*) VARCON
   IF (VARCON.GE.1.AND.VARCON.LE.6) GO TO 170
   WRITE (61,160)
160 FORMAT(' SORRY, YOU MAY ONLY USE VARIABLE NUMBERS 1 THROUGH 6')
   GO TO 140
170 WRITE (61,180) VARDSC(VARCON)
180 FORMAT(' NOW ENTER PAIR OF VALUES TO BE LOWER AND UPPER LIMITS.'/
  -' TABLATION IS CONFINED TO THOSE OFFICERS HAVING A VALUE OF'
  -'1X,A28,' FALLING BETWEEN THESE LIMITS.'/' ?')
   READ (60,*) LOCON,HICON
   IVARCN=VARCON
   IF (LOCON.GT.HICON) GO TO 170
   IF (LOCON.LT.MINTAB(IVARCN)) GO TO 170
   IF (HICON.GT.MAXTAB(IVARCN)) GO TO 170
   IF(IVARCN.GE.3)IVARCN=IVARCN+1
C      THE DATA AREA STILL CONTAINS INFO ON OFFICERS WHO
C      HAVE WASTED OR RETIRED. THE ONLY WAY TO ACCESS THESE
C      BLOKES IS TO ACCESS THEM SPECIFICALLY, USING THE
C      SIGNIFICANT CHANGE INDICATOR VARIABLE.
190 IF(IVARCN.EQ.6.OR.IIVAR.EQ.6)WASTIN=.TRUE.
   DO 220 I = 1,LASTRC
   CALL IN(I)
   IF (SIGCH.LT.4) GO TO 200
   IF (.NOT.WASTIN) GO TO 220
200 IF (REP.EQ.'N') GO TO 210
   IF (ATTRIB(IVARCN).GT.HICON.OR.ATTRIB(IVARCN).LT.LOCON) GO TO 220
210 I1=ATTRIB(IIVAR) - M3
   IF (I1.LE.0) GO TO 220

```

```

      IF (I1.GT.M2) GO TO 220
      TABLE(RANK,I1) = TABLE(RANK,I1) + 1
      IF(I1.LT.I1MIN)I1MIN=I1
      IF(I1.GT.I1MAX)I1MAX=I1
220  CONTINUE
      IF (I1MAX.EQ.0) GO TO 80
      DO 230 I = I1MIN,I1MAX
      DO 230 J = 1,NRANKS
230  TABLE(J,I) = TABLE(J,I) * ISCALE
      CWIDTH= 1
      IF (IVAR.GT.2.AND.IVAR.NE.6) GO TO 250
      WRITE (61,240)
240  FORMAT(' PLEASE ENTER CLASS WIDTH'/' ?')
      READ (60,*) CWIDTH
250  WRITE (JPRINT,260) VARDSC(IVAR),TIME
260  FORMAT (/10X,'TABLE OF NUMBERS OF OFFICERS BY RANK'/
      -      10X,'TABLATED BY ',A28/
      -      10X,'FOR THE YEAR',I6)
      IF( IVAR.EQ.6) IVAR=1
      IF (REP.EQ.'N') GO TO 330
      WRITE (JPRINT,270) VARDSC(VARCON)
270  FORMAT (10X,'WITH VALUES OF ',A28)
      IF(VARCON.EQ.6)VARCON=1
      IF (VARCON=3) 280,300,320
280  WRITE (JPRINT,290) LOCON,HICON
290  FORMAT (10X,'BEING RESTRICTED TO THE RANGE',I3,' THROUGH',I3)
      GO TO 350
300  WRITE (JPRINT,310) (CATNAM(I),I=LOCON,HICON)
310  FORMAT(10X,'BEING RESTRICTED TO THE FOLLOWING:',/(10X,A15))
      GO TO 350
320  WRITE (JPRINT,310) (VARNAM(I,VARCON=3),I=LOCON,HICON)
      GO TO 350
330  WRITE (JPRINT,340)
340  FORMAT (10X,'FOR ALL OFFICERS IN THE AIR FORCE')
350  IF (IVAR.LE.2) WRITE (JPRINT,360) (RANKNM(I),I=1,NRANKS), ' TOTAL'
      IF (IVAR.GT.2) WRITE (JPRINT,370) (RANKNM(I),I=1,NRANKS), ' TOTAL'
360  FORMAT(' CLASS      ',33X,'RANKS'/' LIMITS',9X,8A7)
370  FORMAT(' ATTRIBUTE',33X,'RANKS'/' VALUES',9X,8A7)
      WRITE (JPRINT,380)
380  FORMAT(1X,71(1H-))
      DO 385 I=1,7
385  SUBTOT(I)=0
      DO 430 I = 1,I1MAX,CWIDTH
      I1=I+1
      I2=I+CWIDTH-1
      IF (I2.LT.I1MIN) GO TO 430
      IF(I2.GT.M2) I2=M2
      I1P=I+M3
      I2P=I2+M3
      ISTART=(I-1)*NRANKS +1

```

```

      IF (I.EQ.M2) GO TO 400
      IF (CWIDTH.EQ.1) GO TO 400
      DO 390 II = I1,I2
      DO 390 J = 1,NRANKS
390  TABLE(J,I)=TABLE(J,I)+TABLE(J,II)
      IF (IVAR.LE.2) WRITE (JPRINT,395) I1P,I2P,(TABLE(J,I),J=1,NRANKS),
      * IADD(TABLE,350,ISTART,NRANKS)
395  FORMAT(I3,'-',I3,8X,8I7)
      GO TO 415
400  IF (IVAR.LE.2) WRITE (JPRINT,410) I1P,(TABLE(J,I),J=1,NRANKS),
      * IADD(TABLE,350,ISTART,NRANKS)
410  FORMAT(I5,11X,8I7)
415  IF (IVAR.EQ.3) WRITE (JPRINT,420) CATNAM(I),(TABLE(J,I),
      *J=1,NRANKS),IADD(TABLE,350,ISTART,NRANKS)
      IF (IVAR.GT.3) WRITE (JPRINT,420) VARNAM(I,IVAR-3),(TABLE(J,I),J=
      -1,NRANKS),IADD(TABLE,350,ISTART,NRANKS)
420  FORMAT(1X,A15,8I7)
      DO 425 J=1,NRANKS
425  SUBTOT(J)=SUBTOT(J)+TABLE(J,I)
430  CONTINUE
      WRITE (JPRINT,435) (SUBTOT(I),I=1,NRANKS),IADD(SUBTOT,7,1,7)
435  FORMAT (5X,'TOTALS',5X,8I7)
      WRITE (JPRINT,440)
440  FORMAT(//)
      GO TO 10
      END
CCONTROL BOUNDS
CCONTROL SEGMENT=SEG4
      FUNCTION IADD (ARRAY,NSIZE,LEMENT,NOELS)
      INTEGER ARRAY(NSIZE)
      ISUM=0
      DO 10 J=1,NOELS
10  ISUM=ISUM+ARRAY(LEMENT+J-1)
      IADD=ISUM
      RETURN
      END
CCONTROL SEGMENT=SEG5
      SUBROUTINE GETSYS
C
      COMMON /SYSNAMS/ SYSNAM(14)
      CHARACTER*10 SYSNAM
C
      SYSNAM( 1) = 'LOOKIN
      SYSNAM( 2) = 'ISCALE
      SYSNAM( 3) = 'NEWAST
      SYSNAM( 4) = 'MINTIM
      SYSNAM( 5) = 'PROTAB
      SYSNAM( 6) = 'WASTAB
      SYSNAM( 7) = 'IYOSRC
      SYSNAM( 8) = 'MAXREC

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SYSNAM( 9) = 'MINTAB
SYSNAM(10) = 'MAXTAB
SYSNAM(11) = 'BRCHNM
SYSNAM(12) = 'CATNAM
SYSNAM(13) = 'RANKNM
SYSNAM(14) = 'SIGNAM
RETURN
END
CCONTROL BOUNDS
CCONTROL SEGMENT=SEG6
SUBROUTINE ESTABL
COMMON /BLANK / TIME,TOTAL,NEXTLK,NOINRA(7),NOBRNE(7,25)
INTEGER TIME,TOTAL
COMMON /ESTABL / ESTABL(7,25),ESTRNK(7),ESTCAT(25),ESTOT,
- TARGET(7,25),RNKTGT(7),ATS,INLMAN(7,25),
- NCANDS(3,25)
INTEGER ESTABL,ESTRNK,ESTCAT,ESTOT,TARGET,RNKTGT,ATS
*
COMMON /SYSTEM / NRANKS,NCATS,LOOKIN,INITYE,ISCALE,WASFAC,
- NBRCHS,BRCHCT(25),
- MINTIM(7,25),PROTAB(3,25),
- WASTAB(5,40),JPRINT,KPRINT
INTEGER BRCHCT
COMMON /NAMES / RANKNM(7),CATNAM(25),BRCHNM(5),SIGNAM(5)
CHARACTER*1 RANKNM*6, CATNAM*15, BRCHNM*15, SIGNAM*15
CHARACTER*1 REPLY
INTEGER ETOT(25),TTOT(25),BTOT(25),RANK,CAT
INTEGER ESTLIN(8),ACTLIN(8),TARLIN(8)

C
WRITE (JPRINT,10) TIME
10 FORMAT (35X,'STRENGTH AND ESTABLISHMENT LEVELS'/34X,'FOR ALL C
*ATEGORIES IN THE AIR FORCE'/41X,'FOR THE YEAR',I6/)
DO 20 CAT = 1,NCATS
ETOT(CAT)=0
TTOT(CAT)=0
BTOT(CAT)=0
DO 20 RANK = 1,NRANKS
ETOT(CAT)=ETOT(CAT)+ESTABL(RANK,CAT)
TTOT(CAT)=TTOT(CAT)+TARGET(RANK,CAT)
20 BTOT(CAT)=BTOT(CAT)+NOBRNE(RANK,CAT)
WRITE (JPRINT,21) (RANKNM(I),I=1,NRANKS)
21 FORMAT(/4X,'CATEGORY',11X,5(4X,A6),3X,A6,4X,A6,5X,'TOTALS')
DO 30 J=1,NCATS
IF(J.EQ.1)GO TO 24
IF(BRCHCT(J).EQ.BRCHCT(J-1))GO TO 27
DO 15 I = 1,NRANKS
ESTLIN(NRANKS+1) = ESTLIN(NRANKS+1) + ESTLIN(I)
TARLIN(NRANKS+1) = TARLIN(NRANKS+1) + TARLIN(I)
ACTLIN(NRANKS+1) = ACTLIN(NRANKS+1) + ACTLIN(I)
15 CONTINUE

```

```

WRITE (JPRINT,*) ' '
WRITE(JPRINT,22)
22 FORMAT(1X,103(' '))
WRITE (JPRINT,32) BRCHNM(BRCHCT(J-1)),(ESTLIN(I),ACTLIN(I)
*,I=1,NRANKS+1),(TARLIN(I),ACTLIN(I)-TARLIN(I),I=1,NRANKS+1)
WRITE (JPRINT,22)
24 DO 26 I=1,NRANKS+1
ESTLIN(I)=0
ACTLIN(I)=0
26 TARLIN(I)=0
27 DO 28 I=1,NRANKS
ESTLIN(I)=ESTLIN(I)+ESTABL(I,J)
ACTLIN(I)=ACTLIN(I)+NOBRNE(I,J)
28 TARLIN(I)=TARLIN(I)+TARGET(I,J)
WRITE (JPRINT,*) ' '
30 WRITE (JPRINT,32) CATNAM(J),(ESTABL(I,J),NOBRNE(I,J),I=1,NRANKS),
*,ETOT(J),BTOT(J),(TARGET(I,J),NOBRNE(I,J)-TARGET(I,J),I=1,NRANKS)
*,TTOT(J),BTOT(J)-TTOT(J)
32 FORMAT(1X,A15,' EST/ACT',I5,'/3(I4,I5'/'),
*,2(I3,I6'/'),2(I2,I7'/'),I4/
*,16X,'TARG/BAL',I5,'/3(I4,I5'/'),2(I3,I6'/'),2(I2,I7'/'),I4)
DO 35 I = 1,NRANKS
ESTLIN(NRANKS+1) = ESTLIN(NRANKS+1) + ESTLIN(I)
ACTLIN(NRANKS+1) = ACTLIN(NRANKS+1) + ACTLIN(I)
TARLIN(NRANKS+1) = TARLIN(NRANKS+1) + TARLIN(I)
35 CONTINUE
WRITE (JPRINT,22)
WRITE (JPRINT,32) BRCHNM(NBRCHS),(ESTLIN(I),ACTLIN(I)
*,I=1,NRANKS+1),(TARLIN(I),ACTLIN(I)-TARLIN(I),I=1,NRANKS+1)
WRITE (JPRINT,22)
WRITE (JPRINT,*) ' '
WRITE (JPRINT,40) (ESTRNM(I),NOINRA(I),I=1,NRANKS),ESTOT,
*,TOTAL,(RNKTGT(I),NOINRA(I)-RNKTGT(I),I=1,NRANKS),ATS,TOTAL-ATS
40 FORMAT(6X,'TOTALS EST/ACT',I5,'/3(I4,I5'/'),
*,2(I3,I6'/'),2(I2,I7'/'),
*,I4/16X,'TARG/BAL',I5,'/3(I4,I5'/'),2(I3,I6'/'),2(I2,I7'/'),I4)
WRITE(JPRINT,*) ' '
WRITE(JPRINT,22)
WRITE(JPRINT,*) ' '
RETURN
END

```

C

C THIS IS THE SUBROUTINE THAT ADDS THE COSTS:

SUBROUTINE COSTS

C DECLARE VARIABLES:

```

COMMON /MANC / TIMERA,YOS,RANK,CATGRY,BRANCH,
SIGCH,LG9LTY
COMMON/BLANK / TIME,TOTAL,NOINRA(7),NOBRNE(7,25)
INTEGER TIME,TOTAL
INTEGER TIMERA,YOS,RANK,CATGRY,BRANCH,

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```

-      SIGCH,LGBLTY
COMMON /SYSTEM / NRANKS,NCATS,LOOKIN,INITYE,ISCALE,
-      WASFAC,NBRCHS,BRCHCT(25),
-      MINTIM(7,25),PROTAB(3,25),
-      WASTAB(5,40),JPRINT,KPRINT
INTEGER      BRCHCT
COMMON /INOUT  / IOCORE(7,5000),LASTRC
COMMON /NAMES  / RANKNM(7),CATNAM(25),BRCHNM(5),
-      SIGNAM(5)
CHARACTER*1  RANKNM*6,CATNAM*15,BRCHNM*15,
-      SIGNAM*15,RAAFNM*15
INTEGER*6    SALARY(3,7,6),CTCOST(25,12),
-      BRCOST(5,12),RFCOST(12)
INTEGER*6    TABLE

C
C ZERO THE COST ARRAYS:
DO 60 I = 1,NCATS
DO 65 J = 1,12
    CTCOST(I,J)=0
    IF (I.EQ.1) RFCOST(J) = 0
    IF (I.LE.NBRCHS) BRCOST(I,J) = 0
65  CONTINUE
60  CONTINUE
    RAAFM = ' RAAF TOTAL'

C
C READ IN THE CATGRY TRAINING COSTS:
REWIND 14
DO 40 I = 1,NCATS
    READ (14,*) J,K
    IF (J.NE.I) STOP ' CATEGORY FILE IS INCORRECT'
    CTCOST(J,11) = K
40  CONTINUE

C
C READ IN THE SALARY TABLES:
DO 50 I = 1,3
DO 53 J = 1,NRANKS
DO 55 K = 1,6
    READ(14,*) SALARY(I,J,K)
55  CONTINUE
53  CONTINUE
50  CONTINUE

C
C READ IN AND COMPUTE THE TRAINING, CATGRY, BRANCH & RAAF COSTS
C
DO 70 I = 1,LASTRC
    SIGCH = IOCORE(6,I)
    TABLE = 2
    TIMERA = IOCORE(1,I) +1
    RANK = IOCORE(3,I)
    CATGRY = IOCORE(4,I)

```



```

-19,':',19,':',19,':',112,':',112,':',112,':')
580  FORMAT(' /)
C
C WRITE THE HEADER:
  WRITE(JPRINT,550)
  WRITE(JPRINT,5000) TIME
C WRITE THE CATEGORY COST TABLE:
  WRITE(JPRINT,510)
  WRITE(JPRINT,560)
  WRITE(JPRINT,540)
  WRITE(JPRINT,560)
  DO 140 I = 1,NCATS
    WRITE(JPRINT,570) CATNAM(I),CTCOST(I,1),CTCOST(I,2),
-    CTCOST(I,3),CTCOST(I,4),CTCOST(I,5),
-    CTCOST(I,6),CTCOST(I,7),CTCOST(I,8),
-    CTCOST(I,9),CTCOST(I,10)
  WRITE(JPRINT,560)
140  CONTINUE
C WRITE THE BRANCH COST TABLE:
  WRITE(JPRINT,580)
  WRITE(JPRINT,520)
  WRITE(JPRINT,560)
  WRITE(JPRINT,540)
  WRITE(JPRINT,560)
  DO 150 I = 1,NBRCHS
    WRITE(JPRINT,570) BRCHNM(I),BRCOST(I,1),BRCOST(I,2),
-    BRCOST(I,3),BRCOST(I,4),BRCOST(I,5),
-    BRCOST(I,6),BRCOST(I,7),BRCOST(I,8),
-    BRCOST(I,9),BRCOST(I,10)
  WRITE(JPRINT,560)
150  CONTINUE
C WRITE THE RAAF COST TABLE:
  WRITE(JPRINT,580)
  WRITE(JPRINT,530)
  WRITE(JPRINT,560)
  WRITE(JPRINT,540)
  WRITE(JPRINT,560)
    WRITE(JPRINT,570) RAAFNM,RFCOST(1),
-    RFCOST(2),RFCOST(3),
-    RFCOST(4),RFCOST(5),
-    RFCOST(6),RFCOST(7),
-    RFCOST(8),RFCOST(9),
-    RFCOST(10)
  WRITE(JPRINT,560)
  WRITE(JPRINT,580)
  WRITE(JPRINT,550)
  RETURN
  END

```

APPENDIX H

COST DATA

COST DATA.

PAGE # 1

1, 140000, (CATEGORY, TRAINING COSTS)
2, 85000,
3, 50000,
4, 50000,
5, 45000,
6, 40000,
7, 42000,
8, 6000,
9, 25000,
10, 6000,
11, 25000,
12, 65000,
13, 7000,
14, 12000,
15, 18000,
16, 7000,
17, 6500,
18, 7000,
19, 60000,
20, 48000,
21, 5000,
22, 27000,
23, 22000,
24, 8000,
25, 7000,

22345, (GD FLGOFFS-: SENIORITY 1-6)

23045,

23045,

23045,

23045,

23045,

26415, (FLTLTS)

27265,

28115,

28965,

29815,

31115,

32615, (SQNLDRS)

33515,

34415,

34415,

34415,

34415,

36410, (WGCORS)

37140,

37140,

37140,

37140,

37140,

COST DATA.

PAGE # 2

40565, (GPCATS)

40565,

40565,

40565,

40565,

40565,

45000, (AIRCRES)

45000,

45000,

45000,

45000,

45000,

52000, (AVM+S)

52000,

52000,

52000,

52000,

52000,

19700, (NON GD, MED FLGOFF-S)

20400,

20400,

20400,

20400,

20400,

20400,

23250, (FLT LTS)

24100,

24950,

25800,

26650,

27500,

29000, (SQNLDRS)

29900,

30800,

30800,

30800,

30800,

33300, (WGCDRS)

34300,

34300,

34300,

34300,

34300,

38500, (GPCAPTS)

38500,

38500,

38500,

38500,

38500,

45000, (AIRCRES)

COST DATA.

PAGE # 3

45000,
45000,
45000,
45000,
45000,
52000, (AVM+S)
52000,
52000,
52000,
52000,
52000,
19700, (DENTISTS & DOCTORS FLGOFF-S)
20400,
20400,
20400,
20400,
20400,
20400,
25200, (FLTLTS)
26100,
26950,
27800,
28650,
29500,
32000, (SQNLDRS)
32900,
32800,
32800,
32800,
32800,
37300, (WGCDRS)
38300,
38300,
38300,
38300,
38300,
43500, (GPCAPTS)
43500,
43500,
43500,
43500,
43500,
50000, (AIRCORES)
51000,
51000,
51000,
51000,
51000,
58000, (AVMS)
58000,

COST DATA.

PAGE # 4

58000,
58000,
58000,
58000
00
17

APPENDIX I
ESTABLISHMENT DATA

ESTABLISHMENT DATA.

PAGE # 1

297	195	148	114	41	16	7	818	1	PILOT
145	108	57	53	18	4	2	389	1	NAVIGATOR
58	104	95	45	11	2	1	316	2	AERONAUTICAL
73	95	96	43	11	4	0	322	2	RADIO
24	25	24	10	2	1	0	86	2	ARMAMENT
25	35	23	8	1	0	0	92	2	INSTRUMENT
17	29	8	4	1	0	0	59	2	ELECTRICAL
104	186	153	59	15	2	1	529	3	EQUIPMENT
4	12	11	7	2	1	0	37	3	WORKS
80	137	89	35	3	0	0	343	4	ADMINISTRATIVE
188	74	26	3	0	0	0	293	4	AIR TRAFFIC
31	21	9	5	0	0	0	66	4	AIR DEFENCE
12	35	20	3	0	0	0	70	4	INTELLIGENCE
36	45	31	11	2	0	0	125	4	EDUCATION
22	10	8	2	0	0	0	42	4	GROUND DEFENCE
4	5	4	1	0	0	0	14	4	PHOTOGRAPHIC
3	9	10	2	0	0	0	24	4	POLICE
0	2	4	3	1	0	0	10	4	LEGAL
2	30	32	11	5	1	1	82	5	DOCTOR
1	33	12	4	1	0	0	51	5	DENTIST
61	33	11	3	1	0	0	109	5	NURSE
6	2	4	1	0	0	0	13	5	PHARMACEUTICAL
5	1	0	0	0	0	0	6	5	RADIOGRAPHER
6	1	1	0	0	0	0	8	5	LABORATORY
4	2	0	1	0	0	0	7	5	HYGIENE
3	2	2	1	1	0	0	0	0	PILOT
2	1	1	1	1	0	0	0	0	NAVIGATOR
1	1	1	1	0	0	0	0	0	AERONAUTICAL
1	1	1	1	0	0	0	0	0	RADIO
1	0	1	1	0	0	0	0	0	ARMAMENT
1	0	1	1	0	0	0	0	0	INSTRUMENT
1	0	1	1	0	0	0	0	0	ELECTRICAL
3	2	1	1	1	0	0	0	0	EQUIPMENT
0	0	0	0	0	0	0	0	0	WORKS
2	1	1	1	0	0	0	0	0	ADMINISTRATIVE
2	1	0	0	0	0	0	0	0	AIR TRAFFIC
2	1	0	0	0	0	0	0	0	AIR DEFENCE
1	1	0	0	0	0	0	0	0	INTELLIGENCE
0	2	1	0	0	0	0	0	0	EDUCATION
0	0	0	0	0	0	0	0	0	GROUND DEFENCE
0	0	0	0	0	0	0	0	0	PHOTOGRAPHIC
0	0	0	0	0	0	0	0	0	POLICE
0	0	1	0	0	0	0	0	0	LEGAL
0	0	1	0	0	0	0	0	0	DOCTOR
0	0	1	0	0	0	0	0	0	DENTIST
2	1	0	0	0	0	0	0	0	NURSE
0	0	0	0	0	0	0	0	0	PHARMACEUTICAL
0	0	0	0	0	0	0	0	0	RADIOGRAPHER
0	0	0	0	0	0	0	0	0	LABORATORY
0	0	0	0	0	0	0	0	0	HYGIENE

YEAR#01

ESTABLISHMENT DATA,

PAGE # 2

1	1	1	1	1	0	0	PILOT	YEAR#02
1	1	1	1	0	0	0	NAVIGATOR	
2	1	-1	-1	0	0	0	AERONAUTICAL	
1	1	-1	-1	0	0	0	RADIO	
1	0	-1	0	0	0	0	ARMAMENT	
1	0	-1	0	0	0	0	INSTRUMENT	
0	0	-1	0	0	0	0	ELECTRICAL	
5	10	2	1	0	0	0	EQUIPMENT	
0	0	1	0	0	0	0	WORKS	
4	2	1	1	0	0	0	ADMINISTRATIVE	
2	2	1	0	0	0	0	AIR TRAFFIC	
2	2	1	0	0	0	0	AIR DEFENCE	
0	1	0	0	0	0	0	INTELLIGENCE	
0	4	1	0	0	0	0	EDUCATION	
0	1	0	0	0	0	0	GROUND DEFENCE	
0	1	0	0	0	0	0	PHOTOGRAPHIC	
0	1	0	0	0	0	0	POLICE	
0	0	0	0	0	0	0	LEGAL	
0	1	1	0	0	0	0	DOCTOR	
0	1	0	0	0	0	0	DENTIST	
2	0	0	0	0	0	0	NURSE	
0	0	0	0	0	0	0	PHARMACEUTICAL	
0	0	0	0	0	0	0	RADIOGRAPHER	
0	0	1	0	0	0	0	LABORATORY	
0	0	1	-1	0	0	0	HYGIENE	
5	2	-1	0	0	0	0	PILOT	YEAR#03
2	-1	0	0	0	0	0	NAVIGATOR	
2	-1	-3	0	0	0	0	AERONAUTICAL	
2	-1	-3	0	0	0	0	RADIO	
0	0	-1	0	0	0	0	ARMAMENT	
0	0	0	0	0	0	0	INSTRUMENT	
0	0	0	0	0	0	0	ELECTRICAL	
3	2	1	1	0	0	0	EQUIPMENT	
0	0	0	0	0	0	0	WORKS	
1	0	0	0	0	0	0	ADMINISTRATIVE	
0	0	0	0	0	0	0	AIR TRAFFIC	
0	0	0	0	0	0	0	AIR DEFENCE	
0	1	0	0	0	0	0	INTELLIGENCE	
0	4	0	0	0	0	0	EDUCATION	
0	1	0	0	0	0	0	GROUND DEFENCE	
0	1	0	0	0	0	0	PHOTOGRAPHIC	
0	0	0	0	0	0	0	POLICE	
0	0	0	0	0	0	0	LEGAL	
0	0	0	0	0	0	0	DOCTOR	
0	0	0	0	0	0	0	DENTIST	
0	0	0	0	0	0	0	NURSE	
0	0	0	0	0	0	0	PHARMACEUTICAL	
0	1	0	0	0	0	0	RADIOGRAPHER	
0	0	0	0	0	0	0	LABORATORY	
0	0	0	0	0	0	0	HYGIENE	

ESTABLISHMENT DATA.

PAGE # 3

-5	-8	-3	-1	0	0	0	PILOT	YEAR#04
2	4	1	0	0	0	0	NAVIGATOR	
0	4	-6	0	0	0	0	AERONAUTICAL	
0	4	-5	0	0	0	0	RADIO	
0	2	-12	0	0	0	0	ARMAMENT	
0	2	-12	0	0	0	0	INSTRUMENT	
0	1	-1	0	0	0	0	ELECTRICAL	
4	3	3	1	0	0	0	EQUIPMENT	
0	0	0	0	0	0	0	WORKS	
-2	2	1	1	0	0	0	ADMINISTRATIVE	
0	0	-1	0	0	0	0	AIR TRAFFIC	
0	0	0	0	0	0	0	AIR DEFENCE	
0	0	0	0	0	0	0	INTELLIGENCE	
0	2	0	0	0	0	0	EDUCATION	
0	0	0	0	0	0	0	GROUND DEFENCE	
0	1	0	0	0	0	0	PHOTOGRAPHIC	
0	0	0	0	0	0	0	POLICE	
0	0	0	0	0	0	0	LEGAL	
0	0	0	0	0	0	0	DOCTOR	
0	0	0	0	0	0	0	DENTIST	
0	0	0	0	0	0	0	NURSE	
0	0	0	0	0	0	0	PHARMACEUTICAL	
0	0	0	0	0	0	0	RADIOGRAPHER	
0	0	0	0	0	0	0	LABORATORY	
0	0	0	0	0	0	0	HYGIENE	
-5	-4	-2	-1	1	1	0	PILOT	YEAR#05
0	0	0	0	0	1	0	NAVIGATOR	
2	-4	-12	-1	0	0	0	AERONAUTICAL	
2	-3	-12	-1	0	0	0	RADIO	
1	-1	-1	0	0	0	0	ARMAMENT	
1	-1	-1	0	0	0	0	INSTRUMENT	
1	-1	0	0	0	0	0	ELECTRICAL	
4	2	1	0	0	0	0	EQUIPMENT	
0	0	0	0	0	0	0	WORKS	
1	2	0	0	0	0	0	ADMINISTRATIVE	
0	0	0	0	0	0	0	AIR TRAFFIC	
0	0	0	0	0	0	0	AIR DEFENCE	
0	0	0	0	0	0	0	INTELLIGENCE	
0	-2	0	0	0	0	0	EDUCATION	
0	0	0	0	0	0	0	GROUND DEFENCE	
0	0	0	0	0	0	0	PHOTOGRAPHIC	
0	0	0	0	0	0	0	POLICE	
0	0	0	0	0	0	0	LEGAL	
0	0	0	0	0	0	0	DOCTOR	
0	0	0	0	0	0	0	DENTIST	
0	0	0	0	0	0	0	NURSE	
0	0	0	0	0	0	0	PHARMACEUTICAL	
0	0	0	0	0	0	0	RADIOGRAPHER	
0	0	0	0	0	0	0	LABORATORY	
0	0	0	0	0	0	0	HYGIENE	

ESTABLISHMENT DATA.

PAGE # 4

0	0	0	0	0	0	0	PILOT	YEAR#06
0	0	0	0	0	0	0	NAVIGATOR	
0	0	0	0	0	0	0	AERONAUTICAL	
0	0	0	0	0	0	0	RADIO	
0	0	0	0	0	0	0	ARMAMENT	
0	0	0	0	0	0	0	INSTRUMENT	
0	0	0	0	0	0	0	ELECTRICAL	
0	0	0	0	0	0	0	EQUIPMENT	
0	0	0	0	0	0	0	WORKS	
0	0	0	0	0	0	0	ADMINISTRATIVE	
0	0	0	0	0	0	0	AIR TRAFFIC	
0	0	0	0	0	0	0	AIR DEFENCE	
0	0	0	0	0	0	0	INTELLIGENCE	
0	0	0	0	0	0	0	EDUCATION	
0	0	0	0	0	0	0	GROUND DEFENCE	
0	0	0	0	0	0	0	PHOTOGRAPHIC	
0	0	0	0	0	0	0	POLICE	
0	0	0	0	0	0	0	LEGAL	
0	0	0	0	0	0	0	DOCTOR	
0	0	0	0	0	0	0	DENTIST	
0	0	0	0	0	0	0	NURSE	
0	0	0	0	0	0	0	PHARMACEUTICAL	
0	0	0	0	0	0	0	RADIOGRAPHER	
0	0	0	0	0	0	0	LABORATORY	
0	0	0	0	0	0	0	HYGIENE	
0	0	0	0	0	0	0	PILOT	YEAR#07
0	0	0	0	0	0	0	NAVIGATOR	
0	0	0	0	0	0	0	AERONAUTICAL	
0	0	0	0	0	0	0	RADIO	
0	0	0	0	0	0	0	ARMAMENT	
0	0	0	0	0	0	0	INSTRUMENT	
0	0	0	0	0	0	0	ELECTRICAL	
0	0	0	0	0	0	0	EQUIPMENT	
0	0	0	0	0	0	0	WORKS	
0	0	0	0	0	0	0	ADMINISTRATIVE	
0	0	0	0	0	0	0	AIR TRAFFIC	
0	0	0	0	0	0	0	AIR DEFENCE	
0	0	0	0	0	0	0	INTELLIGENCE	
0	0	0	0	0	0	0	EDUCATION	
0	0	0	0	0	0	0	GROUND DEFENCE	
0	0	0	0	0	0	0	PHOTOGRAPHIC	
0	0	0	0	0	0	0	POLICE	
0	0	0	0	0	0	0	LEGAL	
0	0	0	0	0	0	0	DOCTOR	
0	0	0	0	0	0	0	DENTIST	
0	0	0	0	0	0	0	NURSE	
0	0	0	0	0	0	0	PHARMACEUTICAL	
0	0	0	0	0	0	0	RADIOGRAPHER	
0	0	0	0	0	0	0	LABORATORY	
0	0	0	0	0	0	0	HYGIENE	

ESTABLISHMENT DATA.

PAGE # 5

0	0	0	0	0	0	0	PILOT	YEAR#08
0	0	0	0	0	0	0	NAVIGATOR	
0	0	0	0	0	0	0	AERONAUTICAL	
0	0	0	0	0	0	0	RADIO	
0	0	0	0	0	0	0	ARMAMENT	
0	0	0	0	0	0	0	INSTRUMENT	
0	0	0	0	0	0	0	ELECTRICAL	
0	0	0	0	0	0	0	EQUIPMENT	
0	0	0	0	0	0	0	WORKS	
0	0	0	0	0	0	0	ADMINISTRATIVE	
0	0	0	0	0	0	0	AIR TRAFFIC	
0	0	0	0	0	0	0	AIR DEFENCE	
0	0	0	0	0	0	0	INTELLIGENCE	
0	0	0	0	0	0	0	EDUCATION	
0	0	0	0	0	0	0	GROUND DEFENCE	
0	0	0	0	0	0	0	PHOTOGRAPHIC	
0	0	0	0	0	0	0	POLICE	
0	0	0	0	0	0	0	LEGAL	
0	0	0	0	0	0	0	DOCTOR	
0	0	0	0	0	0	0	DENTIST	
0	0	0	0	0	0	0	NURSE	
0	0	0	0	0	0	0	PHARMACEUTICAL	
0	0	0	0	0	0	0	RADIOGRAPHER	
0	0	0	0	0	0	0	LABORATORY	
0	0	0	0	0	0	0	HYGIENE	
0	0	0	0	0	0	0	PILOT	YEAR#09
0	0	0	0	0	0	0	NAVIGATOR	
0	0	0	0	0	0	0	AERONAUTICAL	
0	0	0	0	0	0	0	RADIO	
0	0	0	0	0	0	0	ARMAMENT	
0	0	0	0	0	0	0	INSTRUMENT	
0	0	0	0	0	0	0	ELECTRICAL	
0	0	0	0	0	0	0	EQUIPMENT	
0	0	0	0	0	0	0	WORKS	
0	0	0	0	0	0	0	ADMINISTRATIVE	
0	0	0	0	0	0	0	AIR TRAFFIC	
0	0	0	0	0	0	0	AIR DEFENCE	
0	0	0	0	0	0	0	INTELLIGENCE	
0	0	0	0	0	0	0	EDUCATION	
0	0	0	0	0	0	0	GROUND DEFENCE	
0	0	0	0	0	0	0	PHOTOGRAPHIC	
0	0	0	0	0	0	0	POLICE	
0	0	0	0	0	0	0	LEGAL	
0	0	0	0	0	0	0	DOCTOR	
0	0	0	0	0	0	0	DENTIST	
0	0	0	0	0	0	0	NURSE	
0	0	0	0	0	0	0	PHARMACEUTICAL	
0	0	0	0	0	0	0	RADIOGRAPHER	
0	0	0	0	0	0	0	LABORATORY	
0	0	0	0	0	0	0	HYGIENE	

ESTABLISHMENT DATA.

PAGE # 6

0	0	0	0	0	0	0	PILOT	YEAR#10
0	0	0	0	0	0	0	NAVIGATOR	
0	0	0	0	0	0	0	AERONAUTICAL	
0	0	0	0	0	0	0	RADIO	
0	0	0	0	0	0	0	ARMAMENT	
0	0	0	0	0	0	0	INSTRUMENT	
0	0	0	0	0	0	0	ELECTRICAL	
0	0	0	0	0	0	0	EQUIPMENT	
0	0	0	0	0	0	0	WORKS	
0	0	0	0	0	0	0	ADMINISTRATIVE	
0	0	0	0	0	0	0	AIR TRAFFIC	
0	0	0	0	0	0	0	AIR DEFENCE	
0	0	0	0	0	0	0	INTELLIGENCE	
0	0	0	0	0	0	0	EDUCATION	
0	0	0	0	0	0	0	GROUND DEFENCE	
0	0	0	0	0	0	0	PHOTOGRAPHIC	
0	0	0	0	0	0	0	POLICE	
0	0	0	0	0	0	0	LEGAL	
0	0	0	0	0	0	0	DOCTOR	
0	0	0	0	0	0	0	DENTIST	
0	0	0	0	0	0	0	NURSE	
0	0	0	0	0	0	0	PHARMACEUTICAL	
0	0	0	0	0	0	0	RADIOGRAPHER	
0	0	0	0	0	0	0	LABORATORY	
0	0	0	0	0	0	0	HYGIENE	

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APPENDIX J
SYSTEM DATA

PAGE # 1

GENERAL DUTIES ENGINEER					EQUIPMENT		SPECIAL DUTIES		MEDICAL	
NO CHANGE		RECRUIT			PROMOTED		WASTED		RETIRED	
0	0	1	1	1	0	MINTAB				
25	40	25	5	5	5	MAXTAB				
2	1	4	4	0	0	0	0	0	4	4
4	5	4	4	4	4	99	MINTIM(n,1)			
4	5	4	4	4	4	99	MINTIM(n,2)			
3	4	4	4	4	4	99	MINTIM(n,3)			
3	4	4	4	4	99	99	MINTIM(n,4)			
3	4	4	4	4	99	99	MINTIM(n,5)			
3	4	4	4	99	99	99	MINTIM(n,6)			
3	4	4	4	99	99	99	MINTIM(n,7)			
4	4	4	4	4	4	99	MINTIM(n,8)			
3	4	4	4	99	99	99	MINTIM(n,9)			
4	4	4	4	99	99	99	MINTIM(n,10)			
4	6	4	99	99	99	99	MINTIM(n,11)			
4	4	4	99	99	99	99	MINTIM(n,12)			
4	4	4	99	99	99	99	MINTIM(n,13)			
2	4	4	4	99	99	99	MINTIM(n,14)			
3	4	4	99	99	99	99	MINTIM(n,15)			
4	4	4	99	99	99	99	MINTIM(n,16)			
4	4	4	99	99	99	99	MINTIM(n,17)			
0	4	4	3	99	99	99	MINTIM(n,18)			
0	2	4	4	3	3	99	MINTIM(n,19)			
0	4	4	4	99	99	99	MINTIM(n,20)			
3	4	4	4	99	99	99	MINTIM(n,21)			
3	4	4	99	99	99	99	MINTIM(n,22)			
4	99	99	99	99	99	99	MINTIM(n,23)			
3	99	99	99	99	99	99	MINTIM(n,24)			
4	4	99	99	99	99	99	MINTIM(n,25)			
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,1)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,2)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,3)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,4)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,5)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,6)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,7)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,8)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,9)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,10)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,11)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,12)							
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,13)							

.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,14)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,15)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,16)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,17)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,18)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,19)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,20)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,21)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,22)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,23)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,24)
.3	.3	.3	PROTAB(FLTTLT-SQNLDR-WGCDR,25)
.010	.071	.088	.068 .176 WASTAB
.018	.062	.050	.019 .055
.014	.250	.091	.032 .237
.000	.036	.038	.152 .097
.007	.025	.044	.081 .190
.024	.018	.000	.079 .111
.120	.053	.000	.047 .200
.075	.097	.100	.083 .029
.044	.063	.088	.167 .167
.080	.040	.023	.061 .071
.060	.071	.000	.000 .100
.072	.088	.021	.047 .000
.056	.022	.000	.012 .000
.056	.056	.065	.012 .000
.056	.013	.058	.000 .000
.024	.014	.019	.049 .033
.000	.000	.024	.040 .000
.021	.000	.023	.025 .000
.063	.000	.000	.038 .025
.063	.000	.062	.107 .000
.259	.292	.308	.500 .750
.167	.200	.182	.360 .000
.115	.229	.188	.292 .330
.132	.145	.214	.250 .250
.458	.167	.250	.389 .000
.147	.036	.100	.300 .166
.091	.250	.375	.150 .800
.093	.281	.389	.417 .000
.063	.133	.278	.388 .000
.029	.115	.417	.083 .000
.045	.300	.750	.290 .100
.020	.038	.250	.000 1.00
.083	.179	.000	.500 .000
.500	.100	.000	.500 .000
.000	.500	.000	.000 .000
.000	.000	1.00	.000 .000
.500	.500	.000	.000 .000
.116	.000	.000	1.00 .000

SYSTEM DATA.

PAGE # 3

.500	.000	.000	.000	.000
1.00	1.00	1.00	1.00	1.00
55	20	15	20	5
69	25	17	20	6
75	30	20	25	7
75	30	20	25	8
75	30	30	35	10
75	30	30	35	10
75	30	30	35	10
75	30	35	40	10
75	30	40	45	10
75	30	40	45	10

55	20	15	20	5	7	7	40	3	40	30	7	7	15	3	2	3	4	6	8	20	2	3	5
69	25	17	20	6	8	8	45	4	45	35	8	8	18	4	3	4	5	7	9	25	3	4	6
75	30	20	25	7	8	8	55	5	45	35	8	9	20	5	5	5	5	9	10	30	5	5	7
75	30	20	25	8	8	8	60	6	45	35	9	9	20	5	5	5	5	10	15	30	6	6	8
75	30	30	35	10	13	8	60	7	45	35	9	9	20	5	5	5	5	10	15	30	5	5	8
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75	30	40	45	10	18	8	65	7	45	35	9	9	20	5	5	5	5	10	15	30	5	5	8
75	30	40	45	10	18	8	65	7	45	35	9	9	20	5	5	5	5	10	15	30	5	5	8

APPENDIX K
RAAF OFFICER MANPOWER DATA

RAAF OFFICER MANPOWER DATA.

PAGE # 1

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0	25	7	19	5	1
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3	33	6	1	1	1
3	32	6	1	1	1
2	30	6	1	1	1
2	32	6	1	1	1
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4	30	5	1	1	1
4	29	5	1	1	1

RAAF OFFICER MANPOWER DATA.

PAGE # 2

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8	31	5	3	2	1

RAAF OFFICER MANPOWER DATA.

PAGE # 3

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6	33	5	3	2	1
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2	22	5	3	2	1
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RAAF OFFICER MANPOWER DATA.

PAGE # 4

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4	19	4	1	1	1

RAAF OFFICER MANPOWER DATA.

PAGE # 5

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1	18	4	1	1	1

RAAF OFFICER MANPOWER DATA.

PAGE # 6

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1	18	4	2	1	1
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1	19	4	2	1	1

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